139935

5/20/96 K.10

[redacted]

SKINNER LANDFILL

West Chester, Butler County, Ohio

Remedial Design

Final Design (100%)
Phase I Report

Volume II of IV
(Part 2)

May 20, 1996

RUST

IV

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             HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                  **
**             HELP MODEL VERSION 3.01   (14 OCTOBER 1994)                  **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                 USAE WATERWAYS EXPERIMENT STATION                        **
**          FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                 **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      c:\SKNR-P.D4
TEMPERATURE DATA FILE:        c:\SKNR-T.D7
SOLAR RADIATION DATA FILE:    c:\SKNR-S.D13
EVAPOTRANSPIRATION DATA:      c:\SKNR-E.D11
  IL AND DESIGN DATA FILE:    c:\SNRSOIL1.D10
OUTPUT DATA FILE:             c:\EQUIV2.OUT
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TIME:  18:24      DATE:   2/15/1996
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By: TJC
CHKD: BER

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     TITLE:  Skinner Landfill Help Model Analysis
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- Baseline Profile
ROD Cap w/24" clay layer

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  12
           THICKNESS                  =      30.00    INCHES
           POROSITY                   =       0.4710 VOL/VOL
           FIELD CAPACITY             =       0.3420 VOL/VOL
           WILTING POINT              =       0.2100 VOL/VOL
           INITIAL SOIL WATER CONTENT =       0.3697 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =   0.419999997000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.96
                  FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.25	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0114	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	300.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	3.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000001000E-06	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.25	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL

INITIAL SOIL WATER CONTENT	=	0.0050	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 300. FEET.

SCS RUNOFF CURVE NUMBER	=	88.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	10.500	ACRES
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	7.760	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.891	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	4.410	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	21.342	INCHES
TOTAL INITIAL WATER	=	21.342	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX	=	4.20	
START OF GROWING SEASON (JULIAN DATE)	=	104	
END OF GROWING SEASON (JULIAN DATE)	=	295	
AVERAGE ANNUAL WIND SPEED	=	9.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	73.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00	%

NOTE: PRECIPITATION DATA FOR CINCINNATI OHIO WAS ENTERED FROM THE DEFAULT DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR CINCINNATI OHIO

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
29.20	31.60	42.00	53.00	64.00	73.00

76.00	75.00	68.00	57.00	45.00	35.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR CINCINNATI OHIO

STATION LATITUDE = 39.10 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1974 THROUGH 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	0.000	0.000	3.537	0.155	0.101	0.379
	0.262	0.476	0.225	0.245	0.037	0.298
STD. DEVIATIONS	0.000	0.000	1.765	0.148	0.121	0.378
	0.349	0.266	0.373	0.284	0.068	0.450
EVAPOTRANSPIRATION						
TOTALS	0.931	0.845	2.015	2.737	2.787	3.409
	3.569	3.195	2.375	2.327	1.583	1.225
STD. DEVIATIONS	0.018	0.080	0.044	0.129	0.729	0.671
	0.065	0.162	0.597	0.227	0.066	0.056
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.8043	0.0000	0.6310	0.9860	0.5253	0.5491
	0.5579	0.8848	0.8767	0.4672	0.2060	1.3898
STD. DEVIATIONS	0.5947	0.0000	0.8844	0.7558	0.2834	0.4129
	0.3999	0.9243	1.2249	0.2821	0.2630	1.0348
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ACROSS LAYER 4

AVERAGES	0.0027	0.0000	0.0022	0.0035	0.0018	0.0019
	0.0019	0.0030	0.0031	0.0016	0.0007	0.0048
STD. DEVIATIONS	0.0020	0.0000	0.0030	0.0027	0.0010	0.0015
	0.0014	0.0032	0.0043	0.0010	0.0009	0.0035

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1974 THROUGH 1978

	INCHES		CU. FEET	PERCENT
PRECIPITATION	40.64	(6.929)	1549070.0	100.00
RUNOFF	5.714	(1.8483)	217807.28	14.061
EVAPOTRANSPIRATION	27.000	(1.4898)	1029100.81	66.433
LATERAL DRAINAGE COLLECTED FROM LAYER 2	7.87809	(3.06439)	300273.219	19.38410
PERCOLATION/LEAKAGE THROUGH FROM LAYER 4	0.00001	(0.00000)	0.245	0.00002
AVERAGE HEAD ACROSS TOP OF LAYER 4	0.002	(0.001)		
PERCOLATION/LEAKAGE THROUGH FROM LAYER 5	0.00001	(0.00000)	0.245	0.00002
CHANGE IN WATER STORAGE	0.050	(2.4000)	1888.22	0.122

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PEAK DAILY VALUES FOR YEARS 1974 THROUGH 1978

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	91476.000
RUNOFF	4.472	170467.6090
DRAINAGE COLLECTED FROM LAYER 2	0.46690	17795.98440
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00590
AVERAGE HEAD ACROSS LAYER 4	0.050	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00590
SNOW WATER	5.61	213742.9220

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4321
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2114

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FINAL WATER STORAGE AT END OF YEAR 1978

LAYER	(INCHES)	(VOL/VOL)
1	11.3352	0.3778
2	0.0050	0.0202
3	0.0000	0.0000
4	10.2480	0.4270
5	0.0012	0.0050
SNOW WATER	0.000	

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Equivalent Values for two barrier layers used in Profile 1

Layer 1 = GCL Layer 2 = 18 in. compacted clay							
Values	Layer 1	Layer 2	T1/X1	T2/X2	Sum	T1 + T2	Te/((T1/X1)+(T2/X2))
Thickness (cm)	0.6	45.72				46.32	18.25 inches
Porosity	0.7500	0.4270	0.800	107.073	107.873		0.4294
Field Capacity	0.7470	0.4180	0.803	109.378	110.181		0.4204
Wilting Point	0.4000	0.3670	1.500	124.578	126.078		0.3674
Initial Soil Water Content	0.7500	0.4180	0.800	109.378	110.178		0.4204
Saturated Hydraulic Conductivitiy	3E-09	1E-07	2.00E+08	4.57E+08	6.57E+08		7.05E-08

BY: BER

CKD: TJC

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**          HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                   **
**           HELP MODEL VERSION 3.01   (14 OCTOBER 1994)                    **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                USAE WATERWAYS EXPERIMENT STATION                         **
**         FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                  **
**                                                                          **
**                                                                          **
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```
PRECIPITATION DATA FILE:      c:\SKNR-P.D4
TEMPERATURE DATA FILE:        c:\SKNR-T.D7
SOLAR RADIATION DATA FILE:    c:\SKNR-S.D13
EVAPOTRANSPIRATION DATA:      c:\SKNR-E.D11
SOIL AND DESIGN DATA FILE:    c:\EQUIV2.D10
OUTPUT DATA FILE:             c:\EQUIV2.OUT
```

```
TIME:  17:47      DATE:   2/13/1996
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BY: TJC
CKD. BER

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     TITLE:  Skinner Landfill Help Model Analysis
```
- Profile #1

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******************************************************************************
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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                      LAYER  1
                                      --------

                         TYPE 1 - VERTICAL PERCOLATION LAYER
                             MATERIAL TEXTURE NUMBER  12
           THICKNESS                   =     24.00   INCHES
           POROSITY                    =      0.4710 VOL/VOL
           FIELD CAPACITY              =      0.3420 VOL/VOL
           WILTING POINT               =      0.2100 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.3691 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.419999997000E-04 CM/SEC
         NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.96
                    FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.25	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0104	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	5.00	PERCENT
DRAINAGE LENGTH	=	300.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	3.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.25	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.25	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL

Profile #1

INITIAL SOIL WATER CONTENT = 0.0050 VOL/VOL
EFFECTIVE SAT. HYD. COND. = 10.0000000000 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #12 WITH A FAIR STAND OF GRASS, A SURFACE SLOPE OF 5.% AND A SLOPE LENGTH OF 300. FEET.

SCS RUNOFF CURVE NUMBER	=	88.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	10.500	ACRES
EVAPORATIVE ZONE DEPTH	=	21.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	7.760	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	9.891	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	4.410	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	9.050	INCHES
TOTAL INITIAL WATER	=	9.050	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX	=	4.20
START OF GROWING SEASON (JULIAN DATE)	=	104
END OF GROWING SEASON (JULIAN DATE)	=	295
AVERAGE ANNUAL WIND SPEED	=	9.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	67.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	73.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	72.00 %

NOTE: PRECIPITATION DATA FOR CINCINNATI OHIO WAS ENTERED FROM THE DEFAULT DATA FILE.

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR CINCINNATI OHIO

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
29.20	31.60	42.00	53.00	64.00	73.00

Profile # 1

76.00	75.00	68.00	57.00	45.00	35.00

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR CINCINNATI OHIO

STATION LATITUDE = 39.10 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1974 THROUGH 1978

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	0.000	0.000	3.537	0.155	0.101	0.379
	0.262	0.476	0.225	0.245	0.037	0.298
STD. DEVIATIONS	0.000	0.000	1.765	0.148	0.121	0.378
	0.349	0.266	0.373	0.284	0.068	0.450
EVAPOTRANSPIRATION						
TOTALS	0.931	0.845	2.015	2.737	2.787	3.409
	3.569	3.195	2.375	2.327	1.583	1.225
STD. DEVIATIONS	0.018	0.080	0.044	0.129	0.729	0.671
	0.065	0.162	0.597	0.227	0.066	0.056
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	0.6335	0.0000	0.8389	0.9069	0.4844	0.5346
	0.6015	0.8476	0.8882	0.4683	0.1410	1.5296
STD. DEVIATIONS	0.5508	0.0000	1.0693	0.7049	0.2928	0.4198
	0.5005	0.8685	1.2878	0.3130	0.2000	1.0965
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Profile #1

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ACROSS LAYER 4

AVERAGES	0.0021	0.0000	0.0029	0.0032	0.0017	0.0019
	0.0021	0.0029	0.0031	0.0016	0.0005	0.0052
STD. DEVIATIONS	0.0018	0.0000	0.0037	0.0025	0.0010	0.0015
	0.0017	0.0030	0.0046	0.0011	0.0007	0.003

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1974 THROUGH 1978

	INCHES		CU. FEET	PERCENT
PRECIPITATION	40.64	(6.929)	1549070.0	100.00
RUNOFF	5.714	(1.8483)	217807.28	14.061
EVAPOTRANSPIRATION	27.000	(1.4898)	1029100.81	66.433
LATERAL DRAINAGE COLLECTED FROM LAYER 2	7.87452	(3.07200)	300137.500	19.37533
PERCOLATION/LEAKAGE THROUGH FROM LAYER 4	0.00000	(0.00000)	0.133	0.00001
AVERAGE HEAD ACROSS TOP OF LAYER 4	0.002	(0.001)		
PERCOLATION/LEAKAGE THROUGH FROM LAYER 5	0.00000	(0.00000)	0.133	0.00001
CHANGE IN WATER STORAGE	0.053	(2.2867)	2024.15	0.131

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PEAK DAILY VALUES FOR YEARS 1974 THROUGH 1978

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	91476.000
RUNOFF	4.472	170467.6090
DRAINAGE COLLECTED FROM LAYER 2	0.63096	24048.86130
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00119
AVERAGE HEAD ACROSS LAYER 4	0.067	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00119
SNOW WATER	5.61	213742.9220

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4321

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2114

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FINAL WATER STORAGE AT END OF YEAR 1978

LAYER	(INCHES)	(VOL/VOL)
1	9.1221	0.3801
2	0.0042	0.0170
3	0.0000	0.0000
4	0.1875	0.7500
5	0.0012	0.0050
SNOW WATER	0.000	

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The equivalence of a sand venting layer and a geocomposite venting layer is similar to the equivalence of a sand drain and a geosynthetic wick drain. The calculation for the equivalence is based on the sand venting layer and the geocomposite venting layer should have the same discharge capacity, Q, (volume of flow per unit time).

Discharge capacity of geocomposite is measured by transmissivity and tested according to ASTM D4716. The test device is shown in Fig. 1

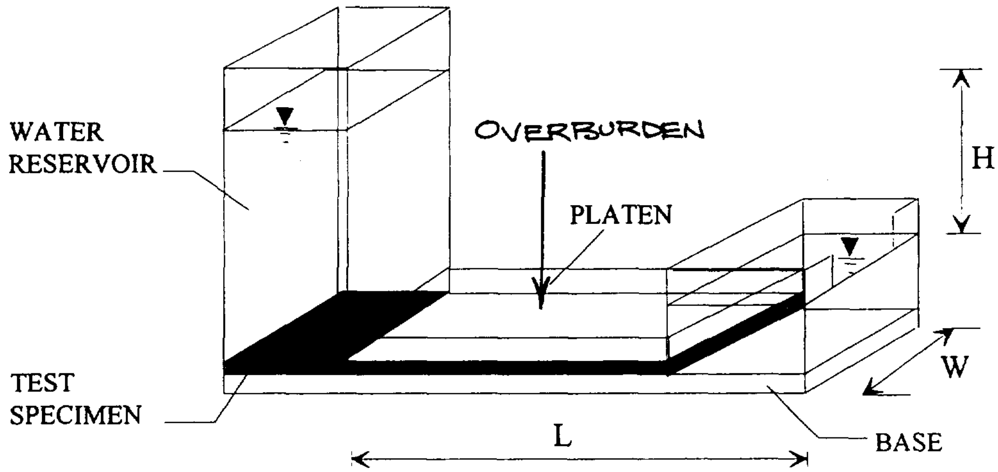


Fig. 1 A constant head hydraulic transmissivity testing device

Discharge capacity for geocomposite is

$$Q = \frac{\theta W H}{L} \qquad (1)$$

Where:
Q = discharge capacity, m^3/s,
W= width of the specimen, m,
θ = hydraulic transmissivity, m^2/s,
H = difference in total head across the specimen, m, and
L = Length of the specimen, m.

With the same device, discharge capacity for sand can be tested.

$$Q = TWK\frac{H}{L} \qquad (2)$$

where:
T = thickness of the specimen, m

K = permeability, m/s.

If Eq. (1) is equal to Eq. (2), then

$TK = \theta$ (3)

If T=6", K=5E-3 cm/s, θ should be equal to or greater than 7.35E-6 m^2/s. The test (attached 3/3) shows the transmissivity for geocomposite is greater than 1.3E-4 m^2/s. Therefore, the sand venting layer can be replaced with a geocomposite layer.

By: SZZ 1/15/96
Ckd: BER 1/17/96

3/3

RUST Environment & Infrastructure
Geosynthetics Laboratory
ASTM D4716 Hydraulic Transmissivity Test Result Summary

Cincinnati Branch
Cincinnati, Ohio 45241
(513) 483-5323
Fax No. (513) 733-8213

Date Tested: 02 DEC 93

Date of Summary: 09 DEC 93

-------- Project Identification --------

Client: Waste Management of Ohio Inc.
Project: Elda Vertical Expansion
RUST Project Number: 71881.300
Specimen Orientation: Machine Direction
Specimen Description: Compacted Clay
PN3002CN Geonet
Textured Coex Seal Geomembrane

-------- Laboratory Parameters --------

Specimen Width: 12 inches
Bearing Medium: Compacted Clay
Water Temperature: 21 C
Temperature Correction: 0.976
Lab Technician: FCE
Checked By: KAD
Gauge Pressure: 1000 psf

-------- R E S U L T S --------

Specimen Number	Elapsed Time (hrs)	Hydraulic Gradient (inches)	Volume Recorded (gal)	Avg. Time Recorded (sec)	Flow Rate (gpm)	Hydraulic Transmisivity (gpm/ft)
1	0.0	0.05	0.065	50.90	0.08	1.50
		0.33	0.130	20.56	0.38	1.12
		1.00	1.000	61.07	0.98	0.96
	0.5	0.05	0.065	50.75	0.08	1.50
		0.33	0.130	20.94	0.37	1.10
		1.00	1.000	61.69	0.97	0.95
	1.0	0.05	0.065	54.25	0.07	1.40
		0.33	0.130	21.47	0.36	1.07
		1.00	1.000	63.66	0.94	0.92
	2.0	0.05	0.065	58.34	0.07	1.30
		0.33	0.130	21.90	0.36	1.05
		1.00	1.000	63.41	0.95	0.92
	5.0	0.05	0.065	55.05	0.07	1.38
		0.33	0.130	22.63	0.34	1.02
		1.00	1.000	67.16	0.89	0.87
	24.0	0.05	0.065	69.10	0.06	1.10
		0.33	0.130	28.38	0.27	0.81
		1.00	1.000	84.03	0.71	0.70

* Note: Only the hydraulic transmissivity values have been adjusted for temperature.

Filename: HTELDA1
Source : QMISC

RUST Rust Environment & Infrastructure

CALCULATION SHEET

PROJECT NO. 72680.508

CLIENT Skinner PRP SUBJECT Cover Design

PROJECT Skinner Landfill

Prepared By FLK Date 2/12/96

Reviewed By SZZ Date

Approved By Date

Design Cover Profile

The cover design profile analyzed in the following pages is shown below. All design calculations were based on this profile being constructed on 3 Horizontal to 1 Vertical (3H:1V) slopes. Materials parameters used in the design analyses are noted in the calculations.

Vegetation

30 inches cover soil Layer a.

Geocomposite Drainage Layer b.

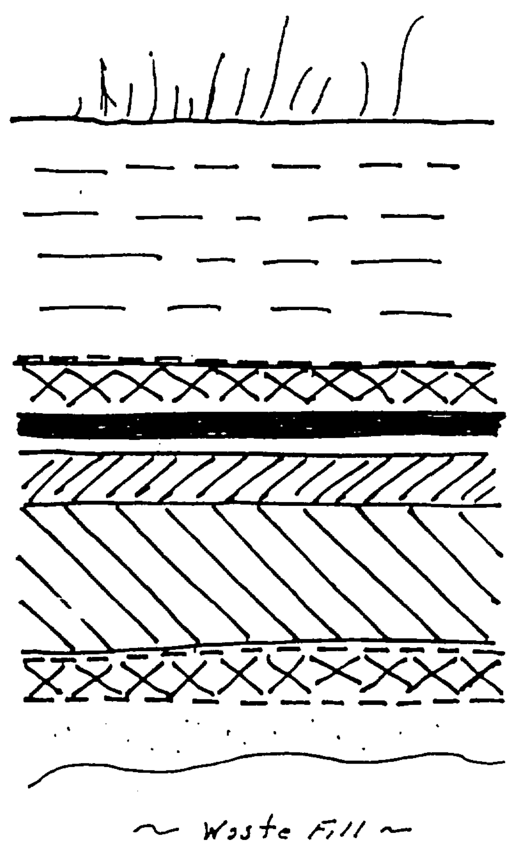
40 mil textured VLDPE * c.

Geosynthetic Clay Layer ** d.

18 inches (1×10^{-7}) cohesive soil e.

Geocomposite Gas Venting Layer f.

Silty Sand Intermediate Cover Layer g.



* Abreviated HDT in these calcs.

** Abreviated GCL in these calcs.

CLIENT Skinner PRP SUBJECT Cover Design Prepared By FLK Date 2/12/96

PROJECT Skinner Landfill Calculations Reviewed By ______ Date ______

Approved By ______ Date ______

Cover Components

1) The cover will consist of seven layers of clay, silty sand, and geosynthetic materials from top to bottom as follows: (See Cover Sketch sheet

a. 30 inch thick cover soil including top soil

b. Geocomposite drainage layer (Non woven Fabric both faces)

c. 40 mil textured VLDPE (HDT)

d. Geosynthetic Clay Layer (GCL) Non Woven Face both sides

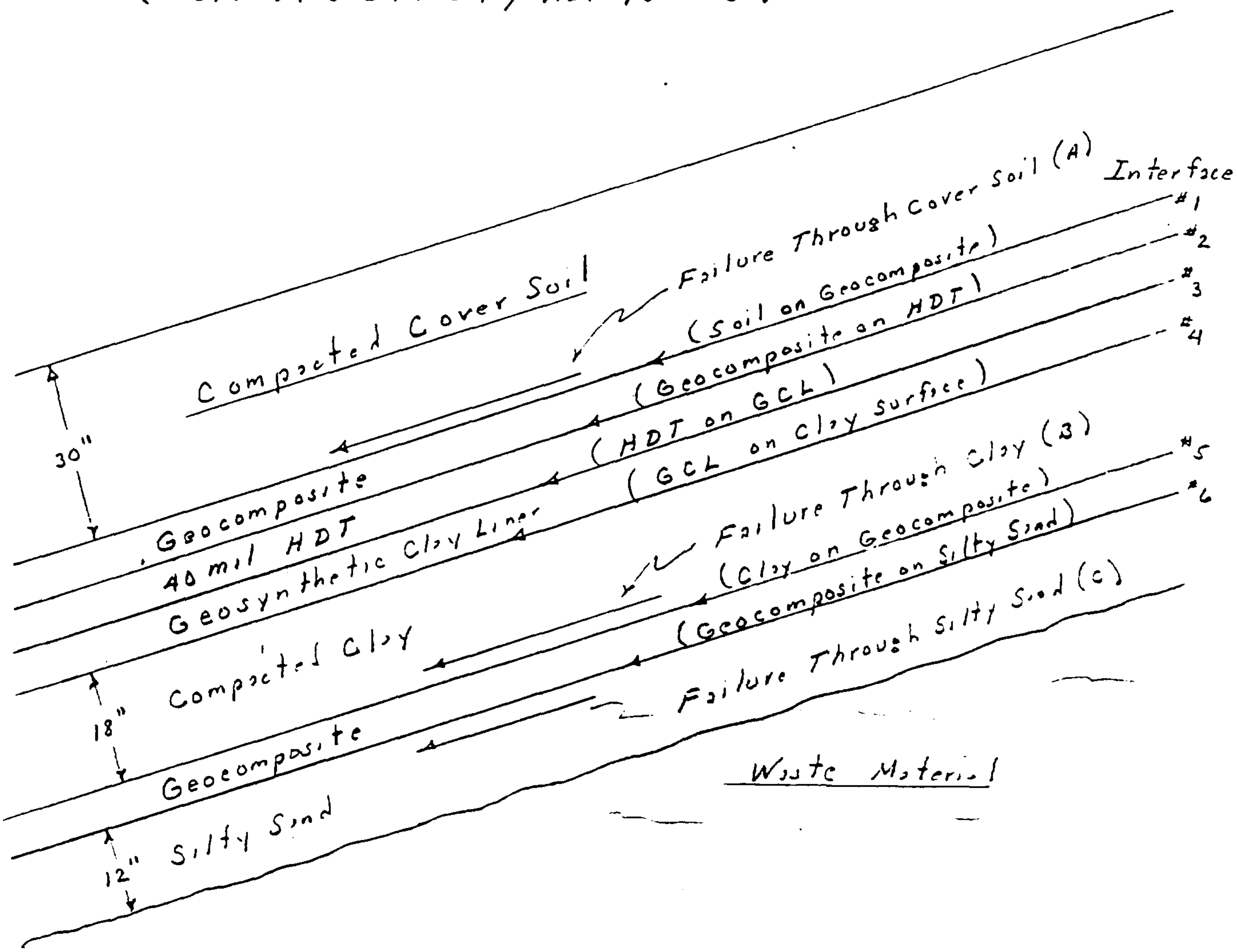
e. 18 inches cohesive soil w hydraulic conductivity of 1×10^{-7} cm/sec

f. Geocomposite gas venting Layer (Non woven Fabric Faces)

g. 12 in minimum thick Silty Sand (waste leveling course)

2) Configuration of cover layers showing potential slide planes which require stability analysis.

(Schematic Sketch / Not to Scale)



RUST Rust Environment & Infrastructure

CALCULATION SHEET

PROJECT NO. 72680.500

CLIENT Skinner PRP SUBJECT Cover Design Calculations

PROJECT Skinner Landfill

Prepared By ELK Date 2/12/96

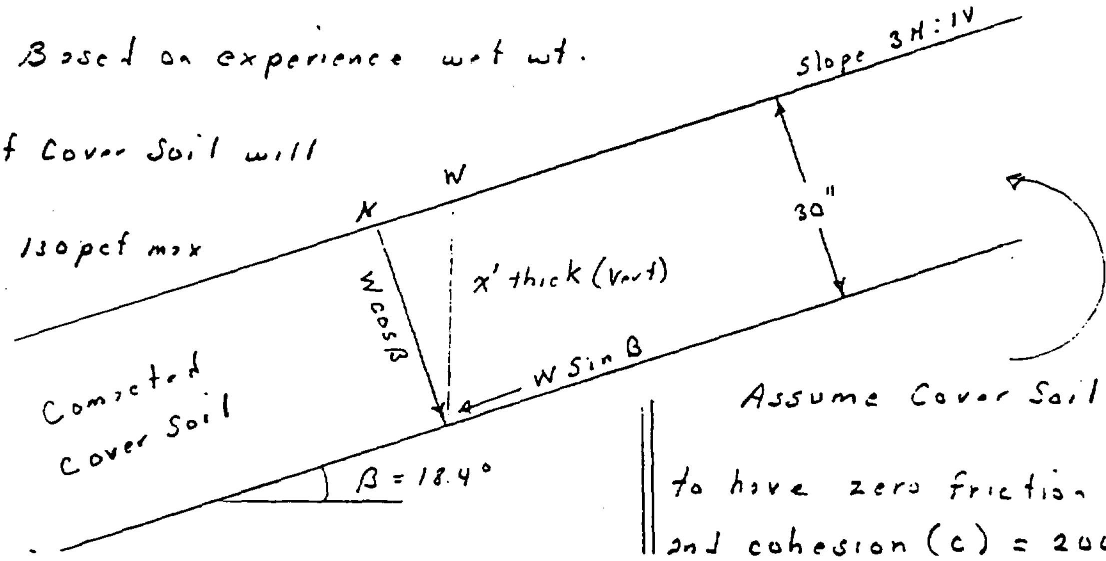
Reviewed By ______ Date ______

Approved By ______ Date ______

Stability Calculations

1. Calculate Cover Soil Normal and Driving Forces

Based on experience wet wt. of Cover Soil will be 130pcf max



Assume Cover Soil to have zero friction ($\phi = 0$) and cohesion (c) = 200 psf

$$x' = \frac{2.5'}{\cos\beta} = \frac{2.5}{0.9489} = 2.635'$$ Vertical Slice Thickness

(Use as conservative value)

$\therefore$ $W = 2.635 \times 130\,pcf = 342.55 \approx 343\,psf$

Normal Force (F_N) = $343 \cos 18.4° = 343(0.9489) = \underline{325\ psf}$

Driving Force (F_D) = $343 \sin 18.4° = 343(0.31565) = \underline{108\ psf}$

2. Calculate Factor of Safety (FS) of failure through cover on basis of infinite slope w failure plane just above Geocomposite layer. This represents worst case since conventional stability analysis (ie, sliding block analysis) for finite "rug slides" prove to have markedly higher FS values.

∴ Minimum FS along plane through cover soil just above Interface #1 (Plane "A") = $\frac{\text{Cohesion of Cover Soil } (c)}{\text{Soil Driving Force } (F_d)}$

saturated Condition

$FS = \frac{200 \text{ psf}}{108 \text{ psf}} = \underline{\underline{1.85}}$ min OK Cover Stability

(Failure Surface "A" on sheet 3)

3. Calculate FS of failure through Compacted Clay Liner (18" Thick) through plane just above lower Geocomposite (Gas Venting) Layer. Ignore shear strength of all the geosynthetic layers between the cover soil and the Clay layer.

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CALCULATION SHEET

PROJECT NO. 72680.500

CLIENT Skinner PRP SUBJECT Cover Design Calculations

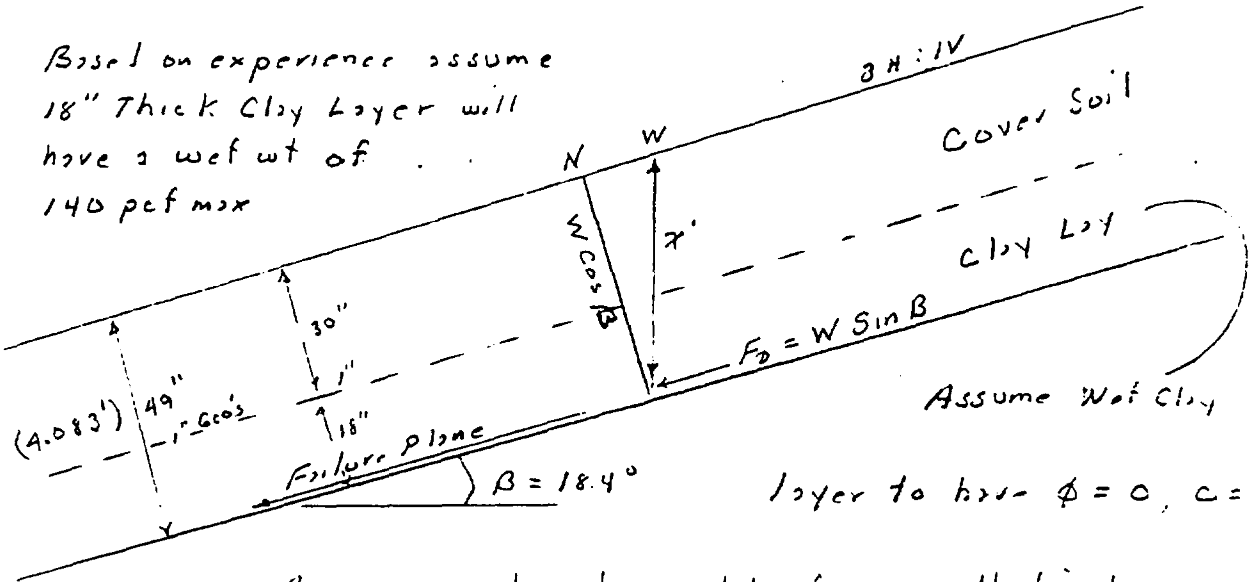
PROJECT Skinner Landfill

Prepared By FLK Date 2/13/96

Reviewed By ______ Date ______

Approved By ______ Date ______

Based on experience assume 18" Thick Clay Layer will have a wet wt of 140 pcf max



Assume Wet Clay layer to have $\phi = 0$, $c = 200$ psf

Assume combined weight of geosynthetic layers to be 5 psf total (very conservative)

$$x' = \frac{4.083'}{\cos\beta} = \frac{4.083}{0.9489} = 4.303' \quad \text{Vertical Slice Thickness}$$

$$\therefore\ W = (2.635' \times 130) + 5_{psf} + (1.59' \times 140\,pcf)$$

(−1" min; max; ↑ min; ↑ max)

$$= 342.55 + 5 + 222.6 = 570$$

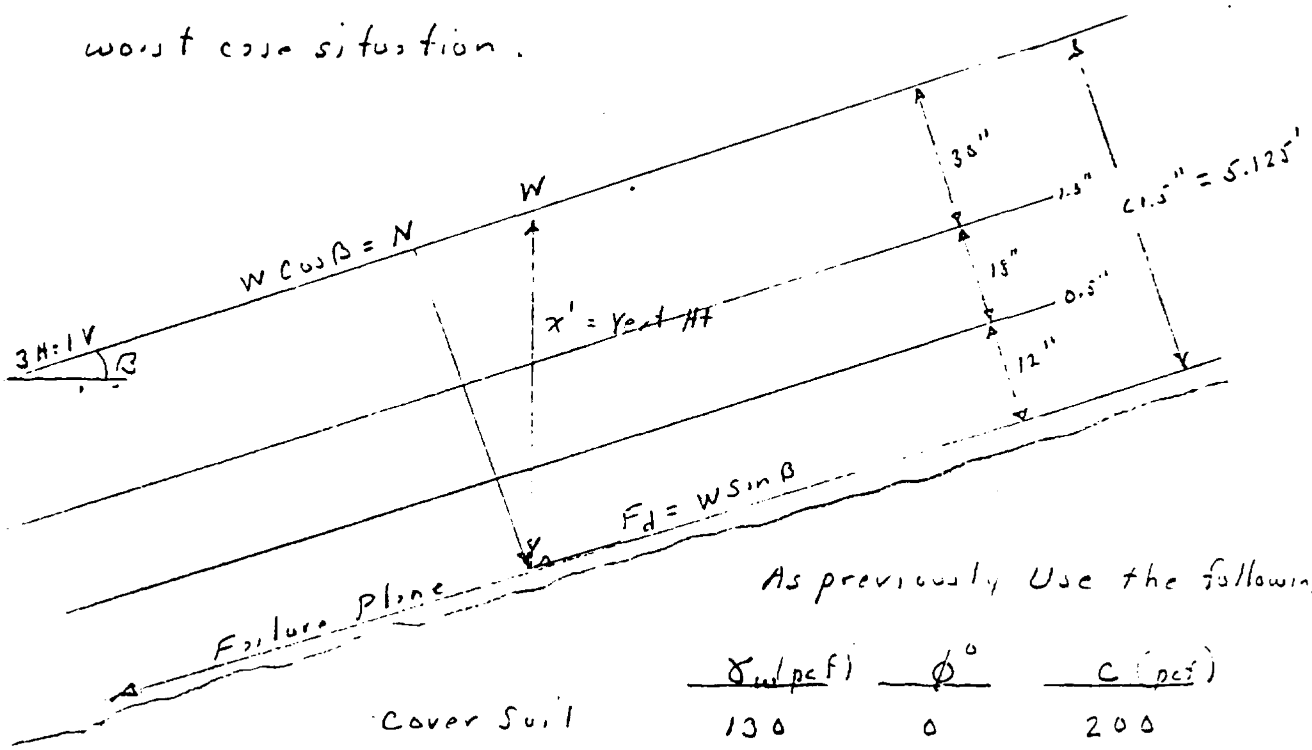
Driving Force (F_D) = 570 sin 18.4° = <u>180 psf</u>

$$FS = \frac{\text{Cohesion of Clay Layer}}{\text{Drive Force } (F_D)} = \frac{200\ psf}{180\ psf} = \underline{\underline{1.11}} < 1.50$$

(Failure Surface "B" p. 3)

Note: FS of 1.11 is not adequate must assume $c = 270$ psf to get $FS > 1.50$ ($c = 300$ is probably achievable), with right soil. This layer probably represents the weak link in this cover design. Soil Selection and placement will be critical.

4) <u>Calculate FS of failure through compacted</u> Silty Sand leveling layer over waste. Assume failure at bottom (-1.0) level just above waste. This is worst case situation.



As previously Use the following

	γw(pcf)	φ°	c (psf)
Cover Soil	130	0	200
Clay Layer	140	0	200
Silty Sand	140	31	80

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CALCULATION SHEET

PROJECT NO. 72680.500

CLIENT Skinner PRP SUBJECT Cover Design Calculations Prepared By FLK Date 2/14/96

PROJECT Skinner Landfill Reviewed By ______ Date ______

Approved By ______ Date ______

$$x' = \frac{5.125}{\cos\beta} = \frac{5.125'}{0.9489} = 5.400'$$

geos, CCL, HDT — geocomp

$$W = (2.635 \times 130\,pcf) + 5\,psf + (2.59 \times 140\,pcf) + 1\,psf$$

$$= 342.55 + 5 + 362.60 + 1 = 711.15 \approx \underline{\underline{711}}\ psf$$

$$\text{Driving force } (F_D) = 711 \text{ Sine } 18.4° = \underline{224}\ psf$$

31° — 80

$$\text{Resisting Force } (F_r) = N \tan\phi + c$$

$$\text{where } N = W\cos\beta = 711\,(0.9489) = \underline{\underline{675}}\ psf$$

$$\therefore F_r = 675\,(0.600) + 80\ psf = \underline{\underline{485.}}\ psf$$

$$FS_{(A)} = \frac{F_r}{F_D} = \frac{485}{224} = \underline{\underline{2.17}} > 1.50 \text{ OK}$$

(Failure Surface "C" on p.3)

5. <u>Calculate Slide FS along Interface #1</u> Soil <u>on top of Geocomposite (Nonwoven Face)</u>

Laboratory Test Values shown in <u>Exhibit 2</u>

Use $\phi = 27°$ $\delta = 110$ psf (conservative values)

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CALCULATION SHEET

PROJECT NO. 72680.500

CLIENT Skinner PRP SUBJECT Cover Design Calculations Prepared By FLK Date 2/14/96

PROJECT Skinner Landfill Reviewed By ______ Date ______

Approved By ______ Date ______

From previous calc.

$\therefore$ Resisting Force $F_1 = N \tan \phi^\circ + \delta$ psf

$F_1 = 325 \tan 27^\circ + 110$ psf

$F_1 = 166 + 110 = 276$ psf

From preceeding Calcs $F_d = 108$ psf

$\therefore FS = \frac{F_1}{F_d} = \frac{276}{108} = \underline{\underline{2.56}} > 1.50$ OK

See p. 3

<u>Sliding Resistance FS is OK for Cover Soil over Geosynthetic Face of Geocomposite (Interface #1)</u>

6. <u>Check Sliding Resistance of Geocomposite on 40 mil HDPE Geomembrane (Interface #2)</u>

Laboratory Test Values for this interface combination are Tabulated in <u>Exhibit 3</u>

Use Friction Angle $\phi = 34^\circ$. Adhesion $\delta = 65$ psf

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CALCULATION SHEET

PROJECT NO. 72680.501

CLIENT Skinner PRP	SUBJECT Cover Design	Prepared By FLK	Date 2/14/96
PROJECT Skinner Landfill	Calculations	Reviewed By	Date
		Approved By	Date

Resisting Force $(F_R) = N \tan\phi + \delta$

$= 325 \tan 34 + 65$

$= 325(0.674) + 65 = \underline{284 \text{ psf}}$

From Preceding Calcs. $F_D = 108$ psf

$\therefore FS = \frac{F_R}{F_D} = \frac{284}{108} = \underline{2.62}$ OK (Does not engage tensile resist. of HDT)

Sliding Resistance FS is OK for Interface #2

7. Check Sliding Resistance of 40 Mil HDT on Geosynthetic Clay Liner (Non Woven Face) Interface #3

Laboratory Test Values for this Interface condition are summarized in Exhibit 4

Use Friction Angle $\phi = 20^{\circ}$ Adhesion $\delta = 0$ psf

∴ Resisting Force $F_3 = N \tan\phi$

$F_3 = 325 \tan 20$

$F_3 = 118.3$ pcf

From Previous Calcs $F_d = 108$ pcf

∴ $FS = \dfrac{F_3}{F_d} = \dfrac{118.3}{108} = \underline{1.10}$ OK (Does not engage tensile resistance of GCL)

Tensile Resistance Available in GCL = 50 ppi (Median Value)

∴ $\dfrac{50\text{ ppi}}{0.24} = 208$ lb/in² of Cross Section

or $50 \times 12 = 600$ lb/LF

Assume only 20% of Available Tensile Strength is developed under extraordinary loading condition ≈ 120 lb/ft

∴ $FS = \dfrac{118.3 + 120}{108} = \underline{\underline{2.20}}$ which is more than adequate.

∴ <u>Resistance along Interface # 3 is OK without internal GCL Resistance and Very Safe with 10% mobilized</u>

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PROJECT NO. 72680.500

CLIENT Skinner PRP SUBJECT Cover Design Prepared By FLK Date 2/15/96

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8. Check Sliding Resistance FS of GCL on Clay, Interface #4 (Nonwoven Face on GCL)

Laboratory Test Values Summarized in Exhibit 2

Use Friction Angle $\phi = 27°$ Adhesion $\delta = 130$

∴ Resisting Force $F_4 = N \tan 27° + 130$

$F_4 = 325(0.509) + 130$

$F_4 = 165 + 130 = \underline{295 \text{ psf}}$

From Preceding Calcs $F_D = 108$

∴ $FS = \frac{295}{108} = \underline{2.73}$ OK Interface #4

GCL with nonwoven fabric side down will be safe from sliding on clay. (If GCL has Woven side down FS Value could be slightly lower but still safe)

Use GCL with nonwoven fabric both faces!

9. Calculate Sliding Resistance FS for Clay Blanket Sliding over Surface of Geocomposite Gas Venting Layer with Nonwoven Side up (Interface #5)

Laboratory Test Values Summarized in Exhibit 2

Use Friction Angle $\phi = 27°$ Adhesion $\delta = 110$

$\therefore$ Resisting Force $F_R = N \tan\phi + \delta$

$N = 342.55 + 5 + (1.59 \times 140) = 570$ psf (See Item 4)

$\therefore F_R = 570(\tan 27°) + 110 = 400$ psf

Driving Force From Previous Calc = 180 psf (Item 3)

$\therefore FS = \frac{F_R}{F_D} = \frac{400}{180} = \underline{\underline{2.22}}$ OK

Clay Blanket Safe from Sliding Failure at interface #5 (on Nonwoven Fabric Side of Geocomposite) Failure would most likely occur within clay blanket as previously calculated.

10. Calculate Sliding Resistance FS for Non Woven Fabric Side of Geocomposite along surface of Silty Sand Leveling Layer. (Interface # 6)

Laboratory Test Values Summarized in Exhibit 2

Use Friction Angle $\phi = 28°$ Adhesion $\delta = 85$ psf

$\therefore$ Resisting Force $F_L = N \tan\phi + \delta$

$= 711(0.532) + 85 = \underline{463}$ psf

From Preceding Calc $F_D = 224$ psf

$\therefore FS = \frac{F_L}{F_D} = \frac{463}{224} = \underline{2.07}$ OK

Geocomposite will be safe from sliding on surface of silty sand Leveling Layer

Construction Loading

1) Calculate Factor of Safety against slide failures during placement of 30 in. thick clay cover using heavy equipment.

Assume Caterpillar Backhoe / Loader 416 Series (4WD) or similar equipment will be used to place 8" loose lifts on top geocomposite layer

Reference : Caterpillar Handbook (Exhibit 6)

∴ Operating Wt = 13708 lb

Assume 50% on Front Tires, 50% on Rear Tires

∴ Load per Axle = 6854 lbs = 3427 lb / tire

∴ Tire Pressure = 51 psi front, 24 psi rear.

∴ Front Contact Area $= \frac{3427 \text{ lb}}{51 \text{ psi}} = 67.2 \text{ in}^2$

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CALCULATION SHEET

PROJECT NO. 72680.500

CLIENT Skinner PRP SUBJECT Cover Design Calculations

PROJECT Skinner Landfill

Prepared By FLK Date 2/15/96

Reviewed By ______ Date ______

Approved By ______ Date ______

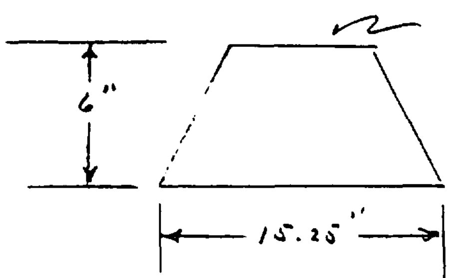
Contact Area $A = \frac{\pi d^2}{4}$; $d = \sqrt{\frac{A \times 4}{\pi}}$

$\therefore$ diameter $= \sqrt{\frac{67.2 \times 4}{3.1416}} = \underline{9.25 \text{ in}}$

Similarly diameter = <u>13.5 in</u> for rear tire

$\therefore$ Front tire load is most critical*

2) Calculate Pressure, Normal and Driving Forces Applied to Geosynthetic's by Front Tire of load through 6" thick layer of compacted clay



circular contact area 67.2 in² or 0.55 ft² ~ d = 9.25"

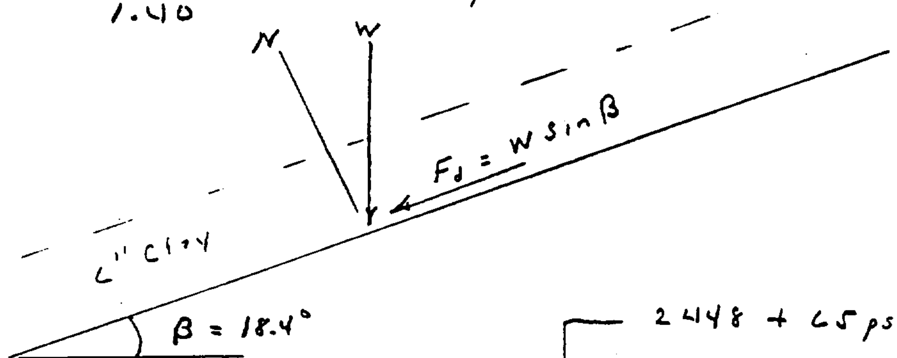
$\therefore$ Area of loading @ surface of Geocomposite = <u>1.40 ft²</u>

* Since width of equipment is 7'5" each tire will act as an independant load on the cover surface.

Since Front Wheel Load = 3427 lb

Normal Load applied to Surface of Geocomposite

$= \frac{3427}{1.40} = 2448$ psf $= W$



2448 + 65 psf (wt. of Clay)

∴ Driving Force $F_d = 2513(0.3156) = \underline{\underline{793 \text{ psf}}}$

Normal Force $F_N = 2513(\cos 18.4) = \underline{\underline{2385 \text{ psf}}}$

.94888

3. <u>Check for Shearing Through Clay Layer (Cover)</u>

Compacted Properly at Correct Moisture Clay

Should have initial properties:

Angle of Internal Friction $\phi = 0$

Cohesion (placed condition) = 1500 psf

$\therefore$ $FS = \dfrac{1500}{793} = \underline{\underline{1.89}}$ OK Safe Against shear failure of clay

4) Check for Shear Resistance along Geocomposite Face

($\therefore$ From item 5 page 8 of these calculations)

Friction $\phi = 27°$ and Adhesion $\delta = 110$ psf

$\therefore$ Resisting Force $F_1 = 2385(\tan 27) + 110$

$F_1 = 2385(0.5095) + 110$

$F_1 = \underline{1325 \text{ psf}}$

From Previous Calc $F_D = 793$ psf

$\therefore$ $FS = \dfrac{1325}{793} = \underline{\underline{1.67}}$ Ok Safe Against along Interface #1 ie

Clay failure along surface of Non Woven Geocomposite

Geonet Compressive Strength $= 15,000 \text{ lb/ft}^2$

$\therefore$ $FS = \dfrac{15,000}{W + clay} = \dfrac{15,000 \text{ psf}}{2513 \text{ psf}} = \underline{\underline{5.969}}$ OK Against compression failure of Geocomposit Geonet

5) Check for Shear Resistence Along Interface #2

(From Item 6 p. 9 these calcs)

Friction $\phi = 34°$ and Adhesion $\delta = 65$ psf

∴ Resisting Force $F_2 = 2385(\tan 34°) + 65$

$F_2 = 2385(0.67451) + 65$

$F_2 = 1673$ lb/ft²

From Previous Calc $F_D = 793$ psf

∴ $FS = \frac{1673}{793} = \underline{\underline{2.11}}$ OK Safe

Against Sliding along Interface #2

6) Check for Shear Resistance Along Interface #3

(From Item 7 p. 10 of these Calcs.)

Friction $\phi = 20°$ Adhesion $= 0$

CLIENT Skinner PRP SUBJECT Cover Design Calculations

PROJECT Skinner Landfill

Prepared By FLK Date 2/15/96
Reviewed By ______ Date ______
Approved By ______ Date ______

$\therefore$ Resisting Force $F_3 = 2385(\tan 20^\circ)$

$F_3 = 2385(0.3640)$

$F_3 = 868$ psf

From Previous Calc $F_D = 793$ psf

$\therefore FS = \frac{868}{793} = \underline{\underline{1.095}}$ OK Safe Against

sliding along Interface #3 however marginal. If

somewhat heavier equipment loads are applied

some tension could be put into GCL.

Since GCL has 50 ppi x 12" = 600 lb/ft

tensile resistance transient stressing of

$FS_{ult} = \frac{868 + 600 \,/\text{ft Wide}}{793} = \underline{\underline{1.85}}$ OK ✓

PROJECT NO. 72680.500

CLIENT Skinner PRP SUBJECT Cover Design Prepared By FLK Date 2/15/96

PROJECT Skinner Landfill Calculations Reviewed By ______ Date ______

Approved By ______ Date ______

8) Check for Shear Resistance Along Interface #4

GCL on Clay Layer.

From Item 8 p. 12 $\phi = 27°$ Adhesion $\delta = 130$ psf

$\therefore$ Resisting Force $F_4 = N \tan 27° + 130$

From Previous Calcs $N = 2385$ psf

$\therefore$ $F_4 = 2385(0.5095) + 130$

$F_4 = 1345$

From Previous Calcs. $F_d = 793$ psf

$$\therefore FS = \frac{F_4}{F_d} = \frac{1345}{793} = \underline{\underline{1.70}} \quad OK$$

Safe Against Interface #4 Sliding

9) Check for Shear Through Clay Just below Interface #4

Assume 1500 psf cohesion in placed clay layer

$$\therefore FS = \frac{1500}{793} = \underline{\underline{1.89}} \quad OK$$

Exhibit 1

Summary of Geosynthetic Design Parameters
from
Geosynthetic Technical Manual
National Seal Company, 1996

Item	
1	Dura Seal HD Geomembrane Specifications
2	Dura Seal HD Geomembrane Physical Properties
3	Tex-Net Geocomposite Properties
4	Bentofix Thermal Lock GCL Data

DURA SEAL® HD GEOMEMBRANE
SPECIFICATIONS

40 mil (1.0 mm)

National Seal Company's DURA SEAL HD high density polyethylene (HDPE) geomembranes are produced from virgin, first quality, high molecular weight resins and are manufactured specifically for containment in hydraulic structures. DURA SEAL HD geomembranes have been formulated to be resistant to chemicals, ultraviolet degradation, as well as leaching additives.

Refer to NSC's Manufacturing Quality Control Manual to determine test methods and frequencies used as a part of NSC's quality control program.

All properties meet or exceed NSF Standard Number 54.

RESIN PROPERTIES	METHOD	UNITS	MINIMUM[1]	TYPICAL
Melt Flow Index[2]	ASTM D 1238	g/10 min	0.50	0.25
Oxidative Induction Time	ASTM D 3895, Al pan, 200°C, 1 atm O_2	minutes	100	120

SHEET PROPERTIES	METHOD	UNITS	MINIMUM[1]	TYPICAL
Thickness	ASTM D 5199			
Average		mils	40.0	41.5
Individual (15' & 30.5')		mils	38.0	40.3
Individual (23')		mils	36.0	40.0
Density	ASTM D 1505	g/cm^3	0.940	0.947
Carbon Black Content	ASTM D 4218	percent	2.0	2.49
Carbon Black Dispersion	ASTM D 5596	rating	A1, A2, B1	A1
Tensile Properties	ASTM D 638			
Stress at Yield		psi	2200	2442
		ppi	88	101
Stress at Break		psi	3800	5012
		ppi	152	208
Strain at Yield	1.3" gage length (NSF)	percent	13.0	16.4
Strain at Break	2.0" gage or extensometer	percent	700	826
	2.5" gage length (NSF)	percent	560	661
Dimensional Stability[2]	ASTM D 1204, NSF mod.	percent	2.0	0.6
Tear Resistance	ASTM D 1004	ppi	750	870
		lbs	30	36
Puncture Resistance	ASTM D 4833	ppi	1800	3084
		lbs	72	128
Constant Load ESCR	ASTM D 5397 (Single Point)	hours	200	>400

1 This value represents the minimum acceptable test value for a roll as tested according to NSC's Manufacturing Quality Control Manual. Individual test specimen values are not addressed in this specification, except thickness.

2 Indicates Maximum Average Roll Value

NSC
NATIONAL SEAL COMPANY
1245 Corporate Blvd. • Suite 300
Aurora, IL 60504
(708) 898-1161 • (800) 323-3820
Fax: (708) 898-3461

DURA SEAL® HD GEOMEMBRANE

PHYSICAL PROPERTIES

40 mil (1.0 mm)

PROPERTIES	METHOD	UNITS	MINIMUM[1]	TYPICAL
Multi-Axial Tensile Elongation	ASTM D 5617	percent	20.0	26.0
Critical Cone Height	ASTM D 5514	cm	1.0	1.5
Wide Width Tensile	ASTM D 4885			
Stress at Yield		psi	2000	2110
Strain at Yield		%	15.0	20.0
Brittleness Temp. by Impact[2]	ASTM D 746	°C	-75	<-90
Coef. of Linear Thermal Exp.[2]	ASTM E 831	$°C^{-1}$	1.5×10^{-4}	1.2×10^{-4}
ESCR, Bent Strip	ASTM D 1693	hours	1500	>10,000
Hydrostatic Resistance	ASTM D 751	psi	300	360
Modulus of Elasticity	ASTM D 638	psi	80,000	131,000
Ozone Resistance	ASTM D 1149, 168 hrs	P/F	P	P
Permeability[2]	ASTM E 96	cm/sec · Pa	3.5×10^{-14}	1.4×10^{-14}
Puncture Resistance	FTMS 101, method 2065	ppi	1300	1639
		lbs	52	68
Soil Burial Resistance[2]	ASTM D 3083, NSF mod.	% change	10	0
Tensile Impact	ASTM D 1822	ft lbs/in^2	250	390
Volatile Loss[2]	ASTM D 1203, A	percent	0.10	0.08
Water Absorption[2]	ASTM D 570, 23°C	percent	0.10	0.04
Water Vapor Transmission[2]	ASTM E 96	g/day · m^2	0.036	0.014

SEAM PROPERTIES	METHOD	UNITS	MINIMUM[1]	TYPICAL
Shear Strength	ASTM D 4437, NSF mod.	psi	2000	2630
		ppi	80	109
Peel Strength	ASTM D 4437, NSF mod.	psi	1500	1880
(hot wedge fusion)		ppi	60	78
Peel Strength	ASTM D 4437, NSF mod.	psi	1300	1590
(fillet extrusion)		ppi	52	66

Seam testing is the responsibility of the installer and/or CQA personnel.

STANDARD ROLL WIDTHS

15 FT. - 23 FT. - 30.5 FT.

The information contained herein has been compiled by National Seal Company and is, to the best of our knowledge, true and accurate. All suggestions and recommendations are offered without guarantee. Final determination of suitability for use based on any information provided, is the sole responsibility of the user. There is no implied or expressed warranty of merchantability of fitness of the product for the contemplated use.

NSC reserves the right to update the information contained herein in accordance with technological advances in the material properties.

4H-0895

NSC

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TEX-NET® SPECIFICATIONS

GEOCOMPOSITE PROPERTIES

PROPERTY	TEST	UNITS	MINIMUM[2]	
			TN3002/1120	TN3002/1125
Thickness	ASTM D 5199	inch	0.275	0.305
Transmissivity[1] (15,000 psf)	ASTM D 4716	m^2/sec	5×10^{-5}	3×10^{-5}
Ply Adhesion	ASTM D 413 or F 904	lb/in	2.0	2.0
Tensile Strength (MD)	ASTM D 4632	lbs	535	580

COMPONENT PROPERTIES[3]

GEONET	TEST	UNITS	PN 3000
Polymer Density	ASTM D 1505	g/cm^3	0.94
Polymer Melt Index (Max)	ASTM D 1238	g/10 min	0.5
Carbon Black Content	ASTM D 4218	%	2.0
Thickness	ASTM D 5199	inches	0.200
Mass Per Unit Area	ASTM D 5261	lbs/ft^2	0.162
Transmissivity[1]	ASTM D 4716	m^2/sec	1×10^{-3} @ 15,000 psf
Tensile Strength	ASTM D 5035	lbs/in	45

GEOTEXTILE	TEST	UNITS	MINIMUM[2]	
			1120	1125
Fabric Weight	ASTM D 5261	oz/yd^2	5.7	7.1
Thickness	ASTM D 5199	mils	75	95
Grab Strength	ASTM D 4632	lbs	160	210
Water Flow Rate	ASTM D 4491	gpm/ft^2	130	110
AOS	ASTM D 4751	Sieve Size mm	70 0.210	70 0.210

1. Measured using water @ 20° C (68°F) with a gradient of one, between two steel plates, after one hour. Value may vary, based on dimensions of the transmissivity specimen and specific Laboratory.
2. These values represent minimum acceptable test values for a roll as tested according to NSC/FSI's Manufacturing Quality Control Manual. Individual test specimen values are not addressed in this specification.
3. Component properties are tested prior to the lamination process. They cannot be tested on the final product.

12/95

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BENTOFIX® THERMAL LOCK TECHNICAL SPECIFICATIONS

GCL DATA

PROPERTY	TEST	STANDARD	UNITS	BENTOFIX NW
Physical				
-Mass Per Unit Area	ASTM D5261	minimum	lb/ft² (g/m²)	1.09 (8820)
-Thickness	ASTM D5199	typical	in (mm)	0.24 (6.0)
Mechanical				
-Grab Tensile[1]	ASTM D4632	typical	lb (N)	210 (928)
-Puncture	ASTM D4833	typical	lb (N)	220 (972)
-Friction Angle[2]	ASTM D5321	minimum	degrees	25
-Peel Strength	ASTM D4632	minimum	lb (N)	15
Hydraulic				
-Water Permeability[3]	GRI GCL-2	maximum	cm/s	1×10^{-9}

COMPONENTS

COMPONENT	TEST	STANDARD	UNITS	BENTOFIX NW
Carrier Geotextile				non-woven[5]
-Mass Per Unit Area	ASTM D5261	minimum	oz/yd² (g/m²)	6.0 (200)
Cover Geotextile				nonwoven
-Mass Per Unit Area	ASTM D5261	minimum	oz/yd² (g/m²)	7.4 (247)
Sodium Bentonite				
-Mass Per Unit Area		minimum	lb/ft² (g/m²)	1.0 (4900)
-Montmorillonite Content	Methylene-Blue	typical	Meq	90
-Moisture Content	ASTM D4643	maximum	%	10
-Swell Index	USP NF XVII	minimum	ml	25
-PlateWater Absorption	ASTM E 946	minimum	%	840
-Fluid Loss	API 13B	maximum	ml	18
-Confined Swell	GRI-GCL 1	minimum	%	350

ROLL SIZE

DIMENSION		STANDARD	UNITS	BENTOFIX NW
-Width x Length[4]		nominal	ft (m)	15.5 x 125 (4.7 x 38.1)
-Area per Roll		minimum	ft² (m²)	1938 (180)
-Packaged Weight		typical	lb (kg)	2150 (977)

NOTES: 10/19/95NW

1. Typical tensile values given for weakest principle direction.
2. Samples hydrated under an initial normal stress of 7.5 psi (50 kPa) and sheared internally.
3. Water permeability values given correspond to effective stress of 30 psi (206 kPa).
4. Nominal roll dimensions exclusive of protective edge area.
5. Non-woven carrier geotextile is woven reinforced.

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Exhibit 2

Summary of Test Results - Rust Geosynthetics Lab

Interfaces 1 and 5

Soil on Non Woven Geotextile

	Noted Soil Description	Residual + (Peak) ϕ (deg)	δ (psf)	
1	Compacted Sub Base Soil	28	85	Use Interface #6
2	Compacted Cover Soil	27	110	Use Interface #1 and #5
		(26)	(130)	
3	Silty Clay	(29)	(560)	
4	Compact Granular Fill	38	60	
		(40)	(105)	
5	Compacted Fill	34	75	
6	Compacted Drainage Sand	(30)	(175)	
7	Compacted Fill	31	80	
8	Compacted Drainage Sand	33	138	
9	Compacted Sand	34	110	
10	Compacted Glacial Till	(37)	(0.8)	

Exhibit 3

Summary of Rust Geosynthetics Laboratory Test Parameters

Geocomposite on HDPE & HDT (Textured)

Interface 2

	Residual & (Peak) Angle (deg)	δ (psf)
HDT		
Textured on Geo Woven	20	173
Textured on " "	19	245
Textured on " "	16	144
Textured on " "	21	317
Textured on " "	22	173
Textured on " "	19	15
	(19)	(15)
HDPE on Woven	13	–
	(12)	(28)
HDPE on Non Woven	10	-
	(11)	(29)
Textured on Geo Woven	(27)	(108)
Textured on Non-Woven	(33)	(105)
Textured on Non Woven	34 (35)	65 (25)

Use Avg. for Interface #2

Exhibit A

Summary of Rüst Geosynthetics Laboratory Test Parameters

GCL on HDPE & HDT

Interface 3

	P Angle	R Angle
GCL Woven on HDPE	16	10
GCL Woven on HDPE	9	9
GCL Woven on Textured HDT	20	16
" "	21	17
" "	20	9*
" "	28	16
GCL Non Woven on HDPE	11	9
GCL Non Woven on Textured	36	36
CCL " " "	34	19

*Tested at very high normal pressures, sheared texture nubs (Interface #3)

(Use Friction Angle = 20° for GCL on HDT)

Exhibit 5

Summary of Rust Geosynthetics Laboratory Test Parameters

GCL on Geocomposite Non Woven Face

Interface 4

	P Angle	R Angle
GCL Woven on #1120 (Nonwoven)	21	16
" Non Woven on #1120 (Nonwoven)	24	21
" " " " #1125 (Nonwoven	20	15

(Use Friction Angle $\phi = 20^\circ$ for Interface #4)

Exhibit 6

Caterpiller Backhoe/Loader Data

416 Series (4WD)

MODEL	428 Series II		438 Series II	
Flywheel Power (Net)	52 kW	70 HP	57 kW	77 HP
Flywheel Power (Gross)	57 kW	76 HP	62 kW	83 HP
Operating Weight*	7143 kg	15,750 lb	7364 kg	16.237 lb
Engine Model — Perkins	4.236		4.236	
Rated Engine RPM	2400		2400	
No. of Cylinders	4		4	
Bore	98.4 mm	3.87 in	98.4 mm	3.87 in
Stroke	127 mm	5 in	127 mm	5 in
Displacement	3.86 L	236 in³	3.86 L	236 in³
Speeds Forward	km/h	mph	km/h	mph
1st	5.2	3.2	5.3	3.3
2nd	9.7	6.0	10.1	6.3
3rd	18.8	11.7	19.5	12.1
4th	29.4	18.3	30.5	18.9
Speeds Reverse				
1st	5.2	3.2	5.4	3.4
2nd	9.8	6.1	10.1	6.3
3rd	19.0	11.8	19.6	12.2
4th	29.6	18.5	30.6	19.0
Turning Radius				
2 wheel drive	3734 mm	12'3"	—	
4 wheel drive	3734 mm	12'3"	3708 mm	12'1"
Tires, Front				
Standard, 2WD	9-16, 10 PR, F2 (outside U.S.A.)		—	
Standard, 4WD	10.5-20, 10 PR, R4		12.5/80-18, 10 PR, I3	
Optional, 2WD	11L-16, 10 PR, F3 (standard U.S.A. 2WD)			
Optional, 4WD	12.5/80-18, 10 PR, I3		—	
Tires, Rear				
Standard, 2 WD	16.9-28, 10 PR, R4		—	
Optional, 2WD	16.9-28, 12 PR, R4		—	
Optional, 2WD			—	
Standard, 4WD	16.9-28, 10 PR, R4		18.4/15-25, 12 PR, R4	
Optional 2WD or 4WD	16.9/14-28, 12 PR, R1 (outside U.S.A.) 16.9-28, 12 PR, R4 (outside U.S.A.)		— —	
Hydraulic system, closed center				
Pump capacity:	108 L/min @ 17 gpm 2400 rpm @ 18 600 kPa (28.5 gpm @ 2400 rpm @ 2700 psi)		135 L/min @ 17 gpm 2400 rpm @ 18 600 kPa (36.4 gpm @ 2400 rpm @ 2700 psi)	

*Includes enclosed ROPS

EXCAVATORS — Bias Ply

For complete tire data and inflation pressures, see the Excavator section in this handbook.

BACKHOE LOADERS — Bias Ply

Model	Tire Size	Ply Rating	Pressure Front kPa	Front psi	Rear kPa	Rear psi
416 Series II (2WD)	11L-16	10	350	52		
	16.9-24	8			195	28
(4WD)	10.5-20	8	352	51		
	19.5L-24	8			165	24
426 Series II (2WD)	11L-16	12	440	64		
	16.9-24	8			195	28
(4WD)	10.5-20	10	428	62		
	19.5L-24	8			165	24
436 Series II (2WD)	11.0-16	12	413	60		
	16.9-28	10			220	32
(4WD)	10.5-20	10	428	62		
	16.9-28	10			220	32
428 Series II (2WD)	9-16	10	413	60		
	16.9-28	10			220	32
(4WD)	10.5-20	10	352	51		
	16.9-28	10			220	32
438 Series II (4WD)	12.5/80-18	10	310	45		
	18.4/15-26	12			207	30
446 (2WD)	14.5/75-16	10	275	40		
	21L-24	12			220	32
(4WD)	12.5-20	10	352	51		
	21L-24	12			220	32

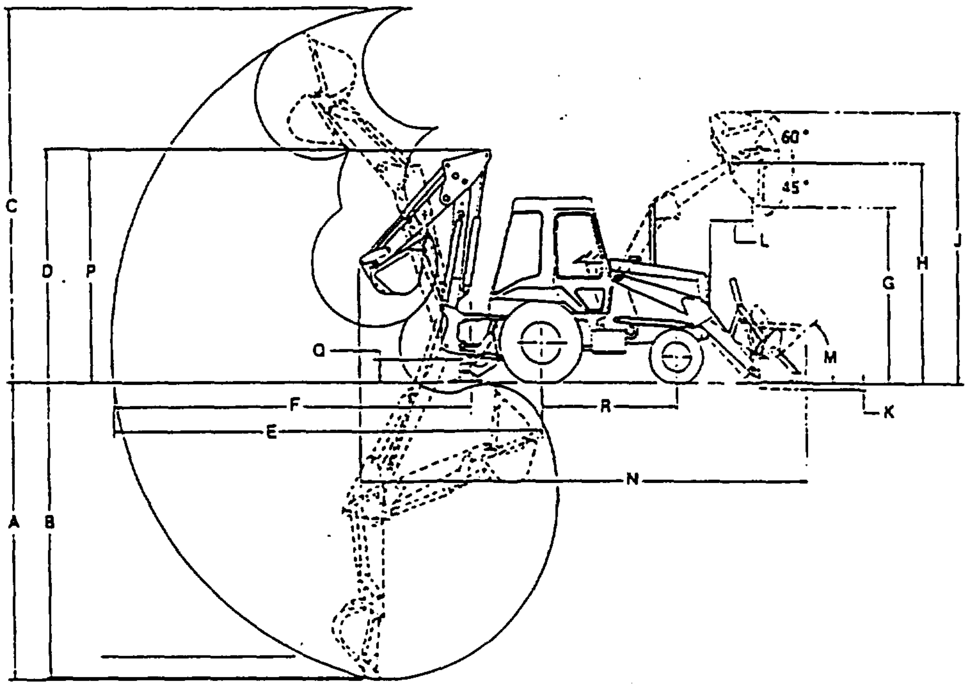
SKIDDERS — Bias Ply

Model	Tire Size	Ply Rating	Pressure Front kPa	Front psi	Rear kPa	Rear psi
518 Cable	18.4-34	10	172	25	172	25
	23.1-26*	10*, 14	138	20	138	20
	28L-26	12, 14	138	20		
	24.5-32	12, 16	172	25		
	30.5L-32	12, 16	138	20		
	66 x 43.00-25	10, 12	138	20		
518 Grapple	23.1-26*	10*, 14	138	20		
	28L-26	12, 14	138	20		
	24.5-32	12, 16	172	25		
	30.5L-32	12, 16	138	20		
	66 x 43.00-25	10, 12	138	20		
528	24.5-32*	16	172	25		
	30.5L-32	16	138	20		

WHEEL TRACTOR-SCRAPERS — Bias Ply

Model	Tire Size	Ply Rating	Pressure Front kPa	Front psi	Rear kPa	Rear psi
613C	18.00-25*	16	345	50	380	55
	23.5-25	16	275	40	275	40
615C	26.5-25*	26	413	60	345	50
	29.5-25	22	310	45	240	35
621E	33.25-29*	26	380	55	310	45
	29.5-29	34	413	60	310	45
	29.5-35	28	380	55	275	40
623E	29.5-29*	34	450	65	345	50
	29.5-35	28	413	60	310	45
627E	33.25-29*	26	413	60	345	50
	29.5-29	34	413	60	450	65
	29.5-35	28	345	50	380	55
631E	37.25-35*	30	380	55	310	45
637E	37.25-35*	30	380	55	380	55
651E	37.5-39	52	550	80	413	60
657E	37.5-39	52	550	80	550	80

*Standard tire and ply rating.



Machine Dimensions	Centerpivot 416 Series II		426 Series II		436 Series II	
N) Overall transport length	6838 mm	22'5"	6917 mm	22'8"	7094 mm	23'3"
P) Overall transport height	3448 mm	11'4"	3742 mm	12'3"	3810 mm	12'6"
Overall width, with bucket	2262 mm	7'5"	2252 mm	7'5"	2262 mm	7'5"
Height to top of canopy/cab	2718 mm	8'11"	2718 mm	8'11"	2779 mm	9'1"
Q) Ground clearance	297 mm	12.0"	291 mm	11.0"	352 mm	14.0"
Front wheel tread	1780 mm	5'10"	1780 mm	5'10"	1800 mm	5'11"
Rear wheel tread	1714 mm	5'7"	1714 mm	5'7"	1714 mm	5'7"
R) Wheel base (2WD)	2100 mm	6'11"	2100 mm	6'11"	2100 mm	6'11"
(4WD)	2067 mm	6'9"	2067 mm	6'9"	2067 mm	6'9"

Machine Dimensions	Centerpivot 446		Sideshift 428 Series II		438 Series II	
N) Overall transport length	7954 mm	26'1"	5685 mm	18'8"	5696 mm	18'8"
P) Overall transport height	4193 mm	13'9"	3574 mm	11'9"	3597 mm	11'10"
Overall width, with bucket	2432 mm	8'0"	2406 mm	7'11"	2406 mm	7'10"
Height to top of canopy/cab	2864 mm	9'5"	2776 mm	9'1"	2795 mm	9'2"
Q) Ground clearance	332 mm	13"	320 mm	12.6"	335 mm	13.2"
Front wheel tread	1970 mm	6'6"	1780 mm	5'10"	1870 mm	6'2"
Rear wheel tread	1800 mm	5'11"	1690 mm	5'6"	1690 mm	5'6"
R) Wheel base (2WD)	2233 mm	7'4"	2100 mm	6'10"	—	—
(4WD)	2233 mm	7'4"	2067 mm	6'9"	2067 mm	6'9"

VII

RUST Rust Environment & Infrastructure

CALCULATION SHEET

PROJECT NO. 72680.500

CLIENT Skinner PRP SUBJECT Settlement Calcs Prepared By RES Date 2-22-96

PROJECT Landfill Cap Reviewed By BER Date 2-28-96

Approved By ______ Date ______

Objective: Estimate maximum differential settlements and resulting strains produced in capping system.

Given: 1) Topography of existing waste.
2) Final cover grading plan.

Assumptions: 1) Differential settlements will occur due to primary consolidation settlement (i.e., immediate & secondary settlements are negligible).
2) Maximum height of waste = 50 ft.

Procedure: Three separate procedures were used to estimate max. differential settlements: two as outlined in the attached technical paper, and the third based on geotechnical theory.

RUST **Rust Environment & Infrastructure**

CALCULATION SHEET

PROJECT NO. ______

CLIENT Skinner PRP SUBJECT Settlement Calcs.

Prepared By ______ Date ______

PROJECT ______

Reviewed By ______ Date ______

Approved By ______ Date ______

Method 1 - 3% & 8% Method.

Maximum Settlement = 0.08 (50-ft)

= 4.0 ft

Minimum Settlement = 0.03 (50-ft)

= 1.5 ft.

Max. Differential Settlement = 4.0 - 1.5

= 2.5 ft.

Reference. "Settlement Analysis for Landfill Geomembrane Covers", attached.

2) Sowers Method

$$TS = \frac{aH}{1+e_o} \log \frac{t_2}{t_1}$$

where
- TS = total settlement (ft)
- a = secondary compression factor
- H = thickness (height) of waste
- e_o = initial void ratio.
- t_2 = time at completion of settlement (month)
- t_1 = " " " " filling (month).

Assume $e_o = 1.5$

$a = 0.09\, e_o = 0.135$

$H = 50$ - ft.

use $t_2/t_1 = 101/12 = 8.4$ (most conservative).

then, most conservative calculated settlement based on Sowers method is:

$$TS = \frac{(0.135)(50')}{1+1.5} \log(8.4) = 2.5 \text{ - ft.}$$

Reference: "Settlement Analysis for Landfill Geomembrane Covers", attached.

RUST **Rust Environment & Infrastructure**

CALCULATION SHEET

PROJECT NO. ______

CLIENT Skinner PRP SUBJECT Settlement Calcs

PROJECT ______

Prepared By ______ Date ______

Reviewed By ______ Date ______

Approved By ______ Date ______

3) GEOTECHNICAL THEORY.

(Ref: Das, "Principles of Geotechnical Engineering, 3rd Ed, PWS Publishing, 1994)

The equation here is:

$$S = \frac{C_c H}{1 + e_o} \log\left(\frac{P_o + \Delta P}{P_o}\right)$$

where
S = settlement
C_c = compression index.
H = thickness (height) of compressible layer.
e_o = initial void ratio
P_o = existing overburden pressure
Δp = pressure increase.

Again, assume $e_o = 1.5$

assume $C_c = 1.0$

$H = 50$ ft

$\overline{P_o} = 25' (85 \text{ pcf}) = 2125$ psf

$\overline{\Delta P_{MAX}} = 10' (125 \text{ pcf}) = 1250$ psf.

CON'T

RUST **Rust Environment & Infrastructure**

CALCULATION SHEET

PROJECT NO. ______

CLIENT ______	SUBJECT ______	Prepared By ______	Date ______
PROJECT ______	______	Reviewed By ______	Date ______
______	______	Approved By ______	Date ______

Note that the calculation assumes an infinite extent of load (so that the pressure increase applied at the surface is seen throughout the depth of waste). This is a conservative assumpt (i.e., overestimates Δp by ~20% at 50-ft depth) for calculating S_{max}.

$$S_{MAX} = \frac{(1.0)(50')}{1 + 1.5} \log\left(\frac{2125 + 1250}{2125}\right)$$

$$= \underline{4.0 \text{ ft.}}$$

Assume that the maximum differential settlement (DS_{MAX}) is equal to the maximum calculated settlement (S_{MAX}) of 4-ft:

$$DS_{MAX} = S_{MAX} = 4 \text{ ft.}$$

(This assumes an adjacent area experiences zero total settlement - conservative).

CON'T.

CALCULATION SHEET

PROJECT NO. ____________

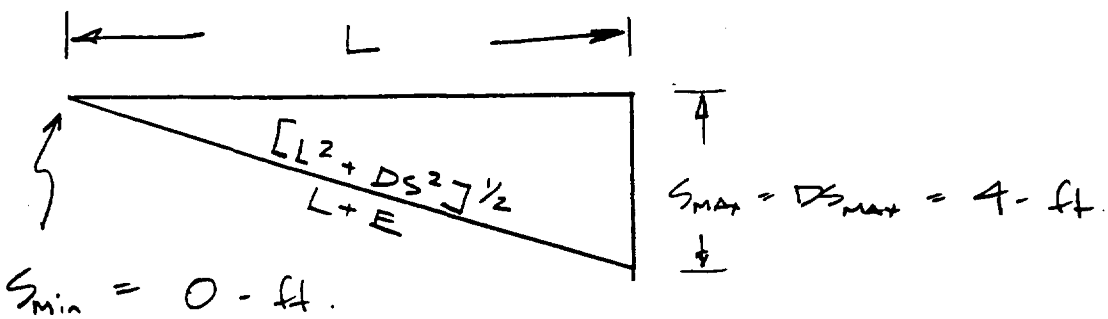
CLIENT Skinner PRP   SUBJECT Settlement Calcs.

PROJECT ____________

Prepared By ______ Date ______

Reviewed By ______ Date ______

Approved By ______ Date ______



Refering to the above figure:

$$\text{Strain} = \left[\frac{(L^2 + DS^2)^{1/2} - L}{L} \right] 100\ \%$$

For strain = 1%, L would need to be:

$$\frac{1}{100} = \left[\frac{(L^2 + 4^2)^{\frac{1}{2}} - L}{L} \right]$$

$$0.01\ L = (L^2 + 4^2)^{1/2} - L$$
$$1.01\ L = (L^2 + 4^2)^{1/2}$$
$$1.01^2\ L^2 = L^2 + 4^2$$
$$1.02\ L^2 = L^2 + 16$$
$$0.02\ L^2 = 16$$
$$L^2 = 800$$
$$L = 28.3\ \text{ft.}$$

∴ A differential settlement of 4-ft would need to take place over ~ 30 ft to produce a strain of 1%.

CONT. →

CALCULATION SHEET

PROJECT NO. ______

CLIENT Skinner PEP SUBJECT Settlement Calcs.

PROJECT ______

Prepared By ______ Date ______
Reviewed By ______ Date ______
Approved By ______ Date ______

Refering to Sheets 8 & 9, the area of deepest fill (labelled Area D - fill depth ≈ 10') is adjacent to areas with avg. fill depths from 4± ft to 8± ft.

Maximum Differential Settlements (conservatively estimated at ≈ 4-ft) would occur over distances on the order of 100± ft. This would produce strains in the capping system of:

$$\text{strain} = \left[\frac{(100^2 + 4^2)^{1/2} - 100}{100} \right] \times 100\%$$

$$= 0.08\%$$

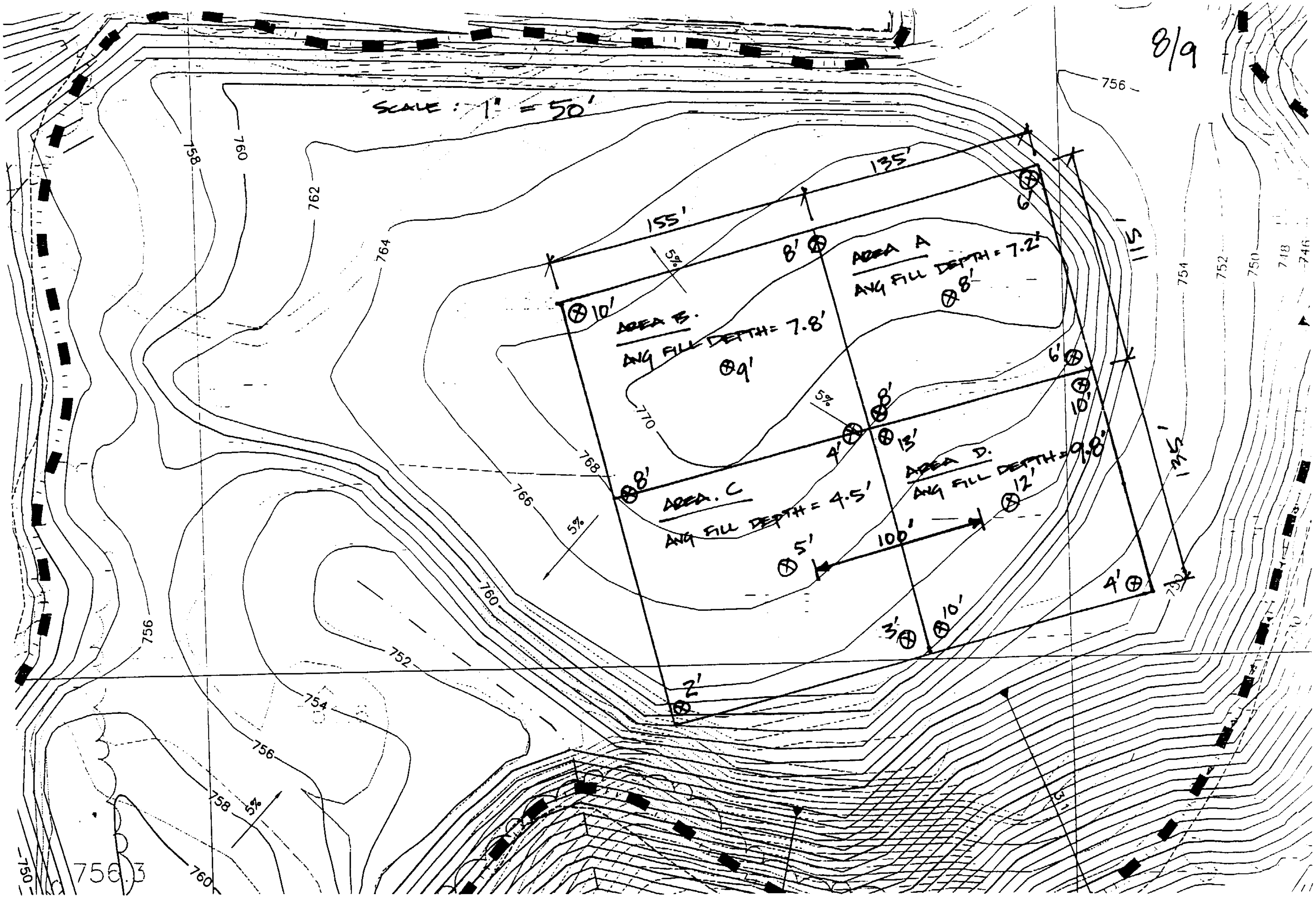
If L = 30' (i.e. 10' fill adjacent to zero fill at 3H:1V slope), strain = 0.9 %.

Conclusion

Under the most conservative conditions considered applicable, strains produced in the capping system due to differential settlements are well below 1% (i.e., on the order of 0.1% ±).

These strains are far below tolerable limits for such a capping system.

Elongation at yield for FML specified is at 13%.
GCL Tensile strain up to 10%.


8/9
SCALE: 1" = 50'
AREA A
AVG FILL DEPTH = 7.2'
AREA B.
AVG FILL DEPTH = 7.8'
AREA. C
AVG FILL DEPTH = 4.5'
AREA D.
AVG FILL DEPTH = 9.8'
155'
135'
115'
135'
100'
5%
756
758
760
762
764
766
768
770
752
754
750
748
746
756.3

RUST **Rust Environment & Infrastructure**

CALCULATION SHEET

PROJECT NO. ______

CLIENT Skinner PRP

SUBJECT Settlement Calcs.

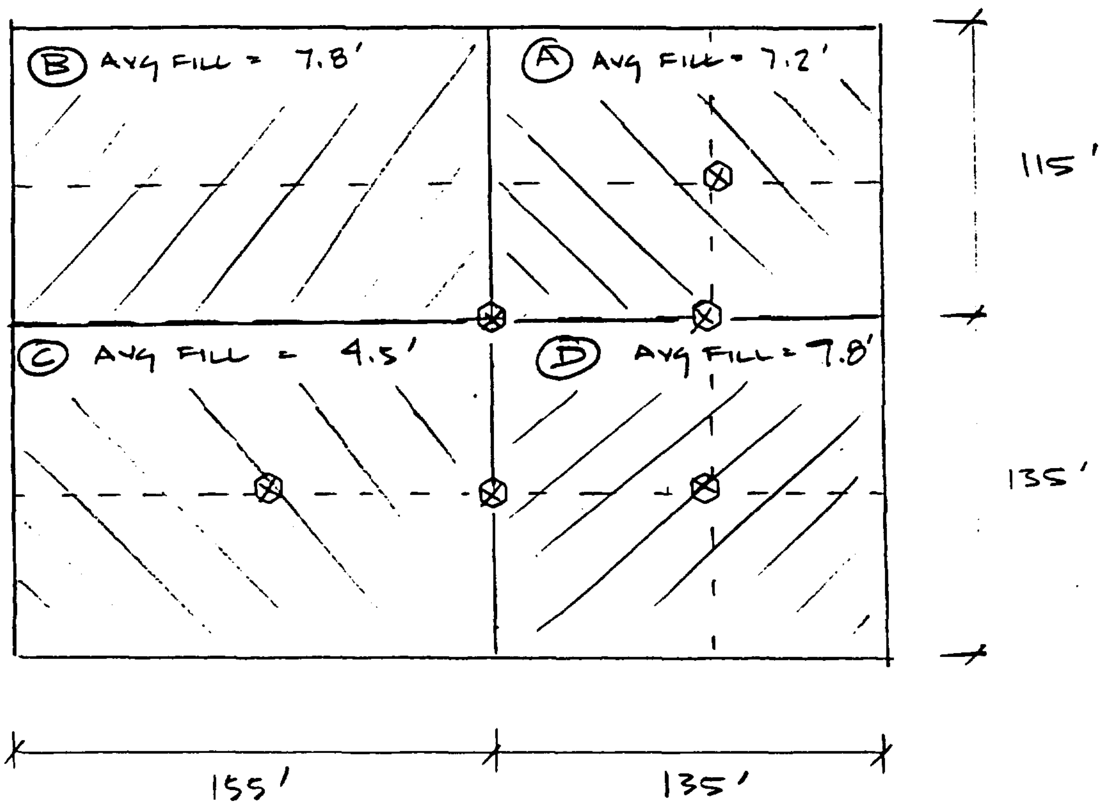
PROJECT ______

Prepared By ______ Date ______

Reviewed By ______ Date ______

Approved By ______ Date ______

Skinner Settlement Model:



For this problem, assume loads due to depth of fill noted above are distributed over a 50-ft avg. depth of waste.

Settlement Analysis for Landfill Geomembrane Covers

by

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Senior Geotechnical Engineer
Fluor Daniel Environmental Services
Chicago, Illinois 60606

Abstract: Current landfill closure regulations frequently require the use of a geomembrane cover to cap an existing landfill. The geomembrane cover design calculations should include an estimate of the magnitude of waste settlement to assess the magnitude of geomembrane elongation resulting from differential settlement of the landfill surface.

The design method presented considers landfill waste characteristics such as type of waste, compactive effort, organic content, void ratio, degree of saturation, specific gravity and water content. Settlement mechanisms discussed include overburden stresses, landfill gas extraction, biological, chemical, physical, and other internal changes. The parameters are compiled and rearranged using standard geotechnical weight/volume relationships to provide values for the estimated maximum total settlement equation. Total settlement is presented as a function of the internal parameters and the log of the filling time ratio.

Finally, the estimates of landfill settlement are used to estimate maximum differential settlement. Differential settlement over a specified cap distance is then used to calculate the percentage of elongation. A factor of safety is applied, and the resulting value is compared to ASTM test results for the proposed type of geomembrane.

INTRODUCTION

This paper presents a uniform approach for estimating the expected magnitude of geomembrane elongation over a specified distance of the landfill cap. The approach is based on estimating minimum and maximum magnitudes of waste settlement to assess geomembrane elongation resulting from differential settlement across the cap. An appropriate geomembrane is then selected based on comparing the proposed material's elongation properties to the estimated magnitude of elongation.

GLOSSARY

Differential Settlement, DS - The vertical difference in feet between the maximum and minimum settlement magnitudes, usually measured across a specified horizontal distance.

Initial Void Ratio, e_o - The ratio within the waste of the volume of voids to the volume of solids.

Degree of Saturation, Sr - The percentage of void space that is filled with water.

Specific Gravity, G - The ratio of the unit weight of solid constituents to the unit weight of water.

Total Settlement, TS - The estimated settlement occurring at a specific location within the landfill, usually referenced to the time period after landfill capping.

Geomembrane Elongation, E - The magnitude of the geomembrane elongation referenced to a specified horizontal distance across the landfill cap.

Percent Elongation, % E - The ratio of elongation to the specified cap distance over which the differential settlement is expected to occur.

MAGNITUDE OF WASTE SETTLEMENT

Causes of Waste Settlement

Settlement of landfill waste material will most likely occur over time due to the following mechanisms:

- o Overburden stresses from the waste and cover soils causing compression and re-orientation of the waste materials.

- o Activation of a landfill gas extraction system causing waste settlement in the extraction well radius of influence.

- o Ongoing biological and chemical decomposition of the waste, physical, mechanical or other internal changes.

The predominant type of waste within the landfill (i.e., ash, hazardous, municipal, construction, etc.), the volume of landfill gas extracted, and the amount of compactive effort applied during placement will also affect the magnitude of settlement. For example, loosely compacted, highly organic, readily biodegradable fills will display much higher settlement than heavily compacted construction debris.

Estimation of Waste Settlement

This paper presents two procedures to predict the magnitude of waste settlement in a landfill. Values from both methods should be calculated and compared.

Three and Eight Percent Method

Based on interviews with landfill surveyors (Hanft, 1991) and past experience from landfill cap construction projects, a quick method to estimate the magnitude of waste settlement is to use the 3 and 8% method. This method assumes simply enough that the minimum settlement is 3% of the total height of waste. The maximum settlement is assumed to be 8% of the total height of waste. These settlements should be estimated to occur after the time the landfill achieves final grade and is capped. In this way the on-going settlements that occur during the filling process do not need to be taken into account.

The differential settlement is calculated as the difference in feet between these maximum and minimum values.

The design engineer should consider the appropriate causes of settlement (i.e. Is there a gas collection system? Is the waste highly organic and readily biodegradable?) when determining the maximum and minimum values, and adjust the percentage limits accordingly.

Recently, a 70 foot thick landfill in central Indiana experienced localized settlements of up to one and one half feet within six months of activating the landfill gas extraction system. (Hanft, 1991) This constitutes a 2% settlement which does not yet take into account the additional long term settlement which is to be expected due to overburden stresses and bio-physical changes.

Sowers Method

A second method for estimating the magnitude of waste settlement was developed in the early 1970's by Sowers, Yen and Scanlon (Sowers, 1973) (Yen and Scanlon, 1975). This method is briefly reviewed here to provide an additional method for estimating of the magnitude of differential settlement. It is the design engineer's responsibility to choose appropriate values for the following geotechnical weight/volume relationships.

Sowers, Yen and Scanlon measured actual settlement rates at several sanitary landfills. They concluded that settlement is a function of the height of fill, the length of the filling period, the suitability of waste for decomposition, and environmental factors such as temperature and moisture content.

Example Calculation for Differential Settlement

Estimate Initial Void Ratio, e_o.

$$e_o = \frac{w\,G}{Sr} \tag{1}$$

Assume the following values for this example calculation:

Sr	(Degree of Saturation),	= 100% (saturation)
G	(Specific Gravity),	= 1.5 to 2.0, say 1.75
w	(Water Content),	= 60%

$$e_o = \frac{(0.60)\ (1.75)}{(1.00)} = 1.05 \quad \text{(This value should be } \geq 1\text{)}$$

Estimate Settlement with Respect to Time.

$$TS = a\,\frac{H}{1+e_o}\,\log_{10}\frac{t_2}{t_1} \tag{2}$$

Where:

TS = Total Settlement (ft)
a = Secondary Compression Factor (a - alpha)
H = Thickness (Height) of Waste (ft)
e_o = Initial Void Ratio
t_2 = Time at completion of settlement (months)
t_1 = Time at completion of filling (months)

Estimate Secondary Compression Factor, "a". "a" is a function of the initial void ratio, e_o. See Figure 1 for graph of "a" vs. e_o.

For conditions "favorable to decomposition

$$\text{"a" max.} = 0.09\ e_o \text{ (approximation only)} \tag{3}$$

For conditions "unfavorable" to decomposition

$$\text{"a" min.} = 0.03\ e_o \text{ (approximation only)} \tag{4}$$

Estimate t_2 and t_1. Actual values based on construction schedules should be used if available. Otherwise, the values listed in Table 1 can be used as approximate values.

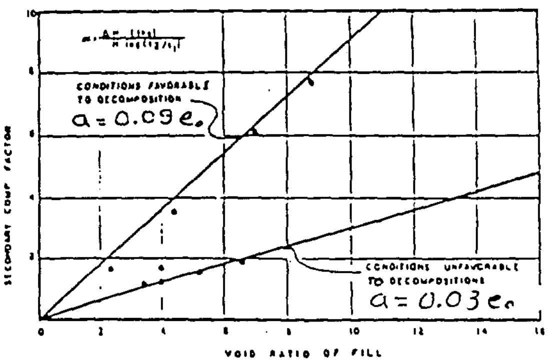

Figure 1. Secondary compression of waste fills (Sowers, 1973)

Table 1. Comparison of settlement and operational filling periods (Yen and Scanlon, 1975)

Thickness of Waste H (ft)	Filling Time t_1 (months)	Approximate Settlement Time t_2 (months)
40-80	12	101
40-80	72	252
80-100	12	233
80-100	72	238

Calculate TS.

Calculate maximum and minimum values of TS using "a" max. and "a" min.

Assuming:

e_o = 1.05
a max = 0.09 e_o = 0.0945
a min = 0.03 e_o = 0.0315
H = 100 ft
t_1 = 24 months
t_2 = 240 months

Using Eq. 2:

$$TS\ max = 0.0945\ \frac{100}{1+1.05}\ \log_{10}\frac{240}{24}$$

$$= 4.6\ ft$$

$$TS\ min = 0.0315\ \frac{100}{1+1.05}\ \log_{10}\frac{240}{24}$$

$$= 1.5\ ft$$

Alternatively, calculate differential settlement between areas of different waste thicknesses using a single "a" value.

Estimate Differential Settlement = DS

Differential Settlement should be estimated conservatively by comparing TS max and TS min with the values achieved by the 3 and 8% method.

Calculate DS by subtracting the minimum settlement from the maximum settlement for each method. To be conservative, use whichever value is greater.

Table 2. Comparison of estimated settlement magnitudes for Sowers and 3 and 8% methods.

Method	Max. Settlement	Min. Settlement	DS
Sowers	TS max = 4.6'	TS min = 1.5'	3.1'
3 & 8%	8% x 100 = 8.0'	3% x 100 = 3.0'	5.0'

CALCULATE GEOMEMBRANE ELONGATION

Calculate the geomembrane elongation (E) for the expected magnitude of DS. The percent elongation will then be the ratio of the estimated elongation to the distance (L) over which the differential settlement is expected to occur.

Use Figure 2 to visualize the relationship between DS, E, and L.

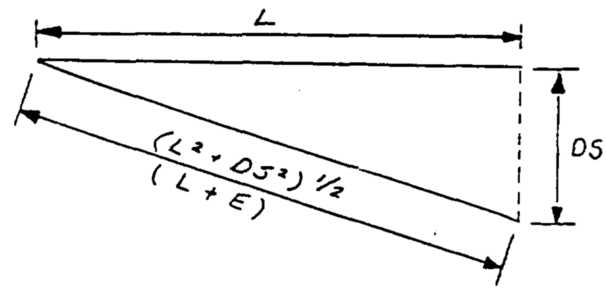

Figure 2. Elongation of cover geomembrane

Example Calculation for Geomembrane Elongation

From Figure 2:

$$(L + E)^2 = L^2 + DS^2 \qquad (5)$$

Therefore:

$$L + E = (L^2 + DS^2)^{0.5}$$
$$E = (L^2 + DS^2)^{0.5} - L \qquad (6)$$

And:

$$\%\ E = \frac{E}{L} \qquad (7)$$

Assume the following values for this example calculation:

DS = 5 ft
L = 15 ft

Note: Selection of the assumed value of "L" should be based on factors including the homogeneity of the waste, waste thicknesses in adjoining areas, gas extraction well radius of influence, and conservative engineering judgement. Lower values of L will provide more conservative values of % E.

Using Eq. 6:

$$E = (15^2 + 5^2)^{0.5} - 15$$
$$= 0.8\ ft.$$

Therefore Using Eq. 7:

$$\%\ E - \frac{0.8}{15} = 5.3\%$$

Selecting a Geomembrane

The estimated value of % E should then be compared to ASTM test results for the proposed geomembrane material (Gundle, 1990). Compare % E to the results of ASTM D 638, % elongation at yield.

A minimum Factor of Safety (FS) of 2 should be used when selecting a geomembrane.

$$\% E_{fs} = \% E * FS \tag{8}$$

Using the values from the previous example problem:

$$\% E_{fs} = 5.3\% * 2$$
$$= 10.6\ \%$$

Therefore in this example, the selected geomembrane should have the capability to elongate a minimum of 10.6% at yield.

SUMMARY

It should be recognized that waste settlement calculations are difficult to evaluate due to the inherent complexities and unknowns involved. Therefore, the approach taken is conservative and will normally lead to high settlement magnitudes. Using this method it is desirable to select a geomembrane with the highest value of elongation at yield for cap designs. Other properties to be evaluated before selecting the geomembrane include: friction, tensile strength, puncture strength, and resistance to the waste materials in the landfill.

Consolidation of the subgrade beneath the landfill should also be calculated to validate the integrity of the leachate collection system grades.

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Gundle Lining Systems Inc., Manufacturer's Literature for Gundline HD, Specifications for Elongation at Yield, 1990.

Hanft, Allan L., Hanft Surveys, Indianapolis, IN. Discussions on Landfill Surveying, June to August, 1991.

Sowers, George F., "Settlement of Waste Disposal Fills." Proceedings, 8th International Conference on Soil Mechanics, Moscow, U.S.S.R., 1973, pp. 207-210.

Yen, Bing C. and Scanlon, Brian, "Sanitary Landfill Settlement Rates." Journal of the Geotechnical Engineering Division, ASCE. May 1975, pp. 475-487.

ACKNOWLEDGEMENTS

Acknowledgements to my current employer, Fluor Daniel Environmental Services for encouraging development of these design methods; to my previous employer Donohue and Associates, for providing an introduction to landfill design; and to Mr. Allan Hanft of Hanft Surveys, for providing recent surveyed results of landfill cap settlements.

VIII

RUST Rust Environment & Infrastructure

CALCULATION SHEET

PROJECT NO. 72680.500

CLIENT SKINNER

SUBJECT SURFACE WATER DRAINAGE CALCULATIONS

PROJECT SKINNER LANDFILL, WEST CHESTER, OHIO

Prepared By MME Date 9-25-95

Reviewed By BER Date 9-25-95

Approved By ______ Date ______

PROBLEM STATEMENT:

DETERMINE SURFACE WATER RUNOFF FROM DRAINAGE AREAS AND SIZE DRAINAGE SWALES ACCORDINGLY.

TYPICAL CALCULATIONS:

(1) SURFACE WATER RUNOFF

- CALCULATE RUNOFF FLOWS USING RATIONAL METHOD

$Q = ciA$

Q = flow in cfs

c = 0.44 for vegetated clay cap

i = duration based on time of concentration

A = area in acres

(2) SWALE SIZING USING MANNING'S EQUATION WITH VARIABLE "N" VALUES BASED ON VEGETATIVE RETARDANCE

Swale a-b: $Q_{100} = 38.12$ cfs

Channel slope: 30 ft Drop in elevation in 450 ft = 0.067 ft/ft

Side slope: 3:1

Bottom Width: 8 ft

Determine Depth using retardance curve B; d = 1.0 ft for Q_{100}, V = 3.6

C; d = 0.7 ft for Q_{100}; V = 5.5

D; d = 0.6 ft for Q_{100}; V = 6.1

See Attachment A

SITE LAYOUT - THE SITE IS DIVIDED UP INTO THREE (3) WATERSHED AREAS BASED ON TOPOGRAPHY AND PROPOSED SWALE LAYOUT. THE FOLLOW CALCULATIONS COVER EACH WATERSHED WHICH ARE:

EASTERN Pages 2, 3, & 4

WESTERN Pages 5, 6, 7, 8, & 9

CENTRAL Pages 10, & 11

Rust Environment & Infrastructure

CALCULATION SHEET

PROJECT NO. 72680.500

CLIENT Skinner PRP Group

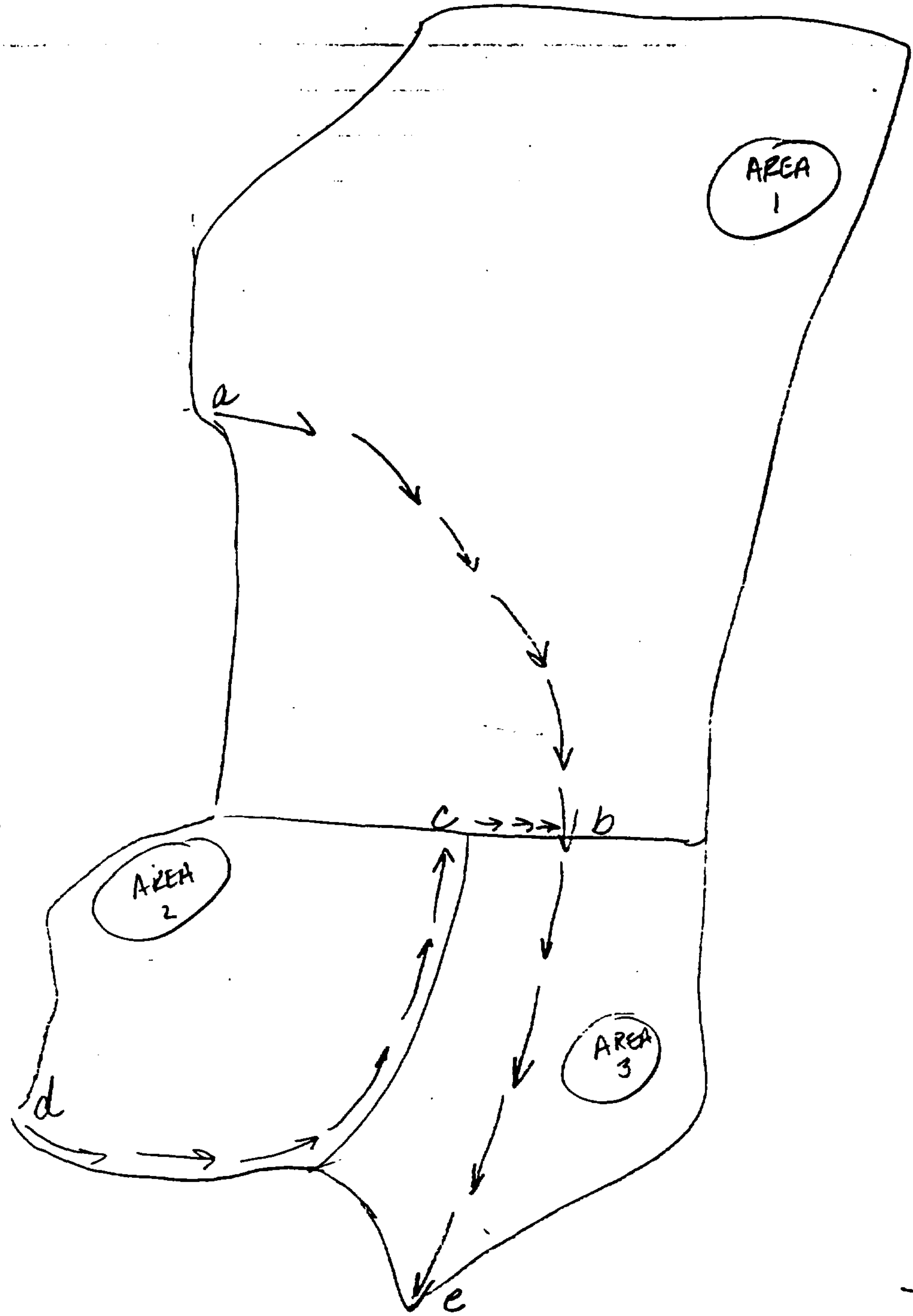
PROJECT Skinner Landfill Remedial Design

SUBJECT EASTERN WATERSHED - Surface Water Drainage Calculations

Prepared By MME Date 9-25-95

Reviewed By BER Date 9-25-95

Approved By ______ Date ______



AREAS
1 = 11.40 ~~10.85~~ acre
2 = 1.77 acre
3 = 1.84 acre
Total = 15.01

CLIENT Skinner PRP Group
SUBJECT Surface Water Drainage Calculations Eastern Watershed
PROJECT Skinner Landfill Remedial Design
Prepared By MME Date 9/25/95
Reviewed By BER Date 10/4/95
Approved By ____ Date ____

Calculate runoff flows using Rational Method

$Q = ciA$ c = runoff coefficient = 0.44 grassed
i = rainfall duration based on time of concentration, T_c
A = watershed area in acres

Compute flow, Q = cfs

Swale a-b   Area = 11.4 acres
t_c = 60' in 1000' ⇒ 9 min (see nomagraph attachment B)
i_{100} = 8.0 in./hour (see rainfall-duration-intensity curve for cincinnati, attachment c)

$Q = (0.44)(8.0)(11.4) = 40.1$ cfs

Swale d-c & c-b   Area = 1.77
t_c = 6' in 300' + 10' in 150' + 6' in 150'
= 6 min. + 2 min. + 1.5 min. = 9.5 min
i_{100} = 7.5

$Q = (0.44)(1.77)(7.5) = 5.8$ cfs

Swale b-e   Area = 15 acres
t_c = 20' in 350' + 60' in 1000' = 4 min + 9 min = 13 min.
i_{100} = 6.8

$Q = (0.44)(15)(6.8) = 44.9$ cfs

RUST ENVIRONMENT & INFRASTRUCTURE — **CALCULATION SHEET**

PROJECT NO. 72680.500		
CLIENT SKINNER PRP GROUP	SUBJECT Eastern Watershed	Prepared By MME Date 9/25/95
PROJECT Skinner Landfill	Surface Water Drainage	Reviewed By BER Date 10/4/95
Remedial Design	Calculations	Approved By ____ Date ____

Swale Sizing

Swale	Q_{100} (cfs)	channel slope (ft/ft)	channel sideslope	bottom width (ft)	depth (ft)/Velocity (fps) Retardance B	C	D
a - b	40.1	0.08	3:1	6	1.0/4.5	0.75/6.5	0.7/7.1
d - c	5.8	0.02	3:1	0	1.4/0.6	1.1/1.0	0.9/1.5
c - b	5.8	[see below for sizing using critical flow equation]					
b - e	44.9	0.05	3:1	6	1.2/3.9	0.9/5.8	0.85/6.2

Swale c-b is on a 3:1 slope (33% channel slope) which will result in critical flow Manning's Equation is not valid, therefore must use critical flow equation

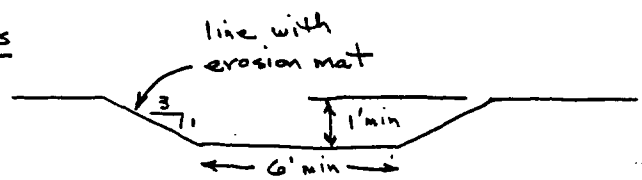
$V = \sqrt{gD}$ $\quad V = \frac{Q}{A}$ $\quad A = WD$ $\quad$ W = channel width, D = channel depth

choose D and solve for W, D = 0.5 ft ⇒ W = 0.4986 Q

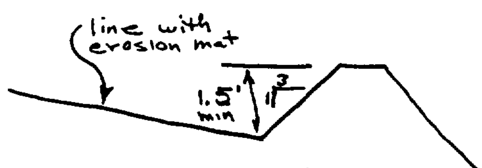
c-b Q_{100} = 5.8 W = (0.4986)(5.8) = 2.9 ft say 3 ft min.

Swale sizes & shapes

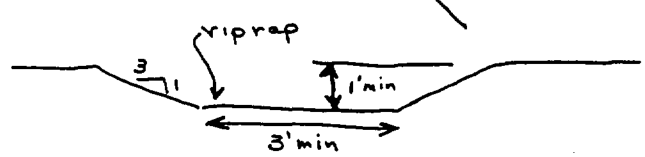
a-b Trapezoidal



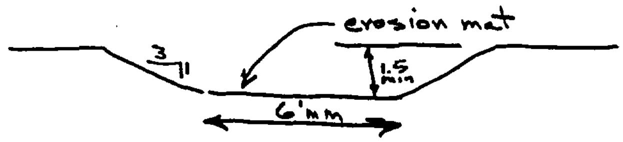
d-c "V" shape



c-b trapezoidal



b-e trapezoidal



RUST Rust Environment & Infrastructure

CALCULATION SHEET

PROJECT NO. 72680.500

CLIENT Skinner PRP Group

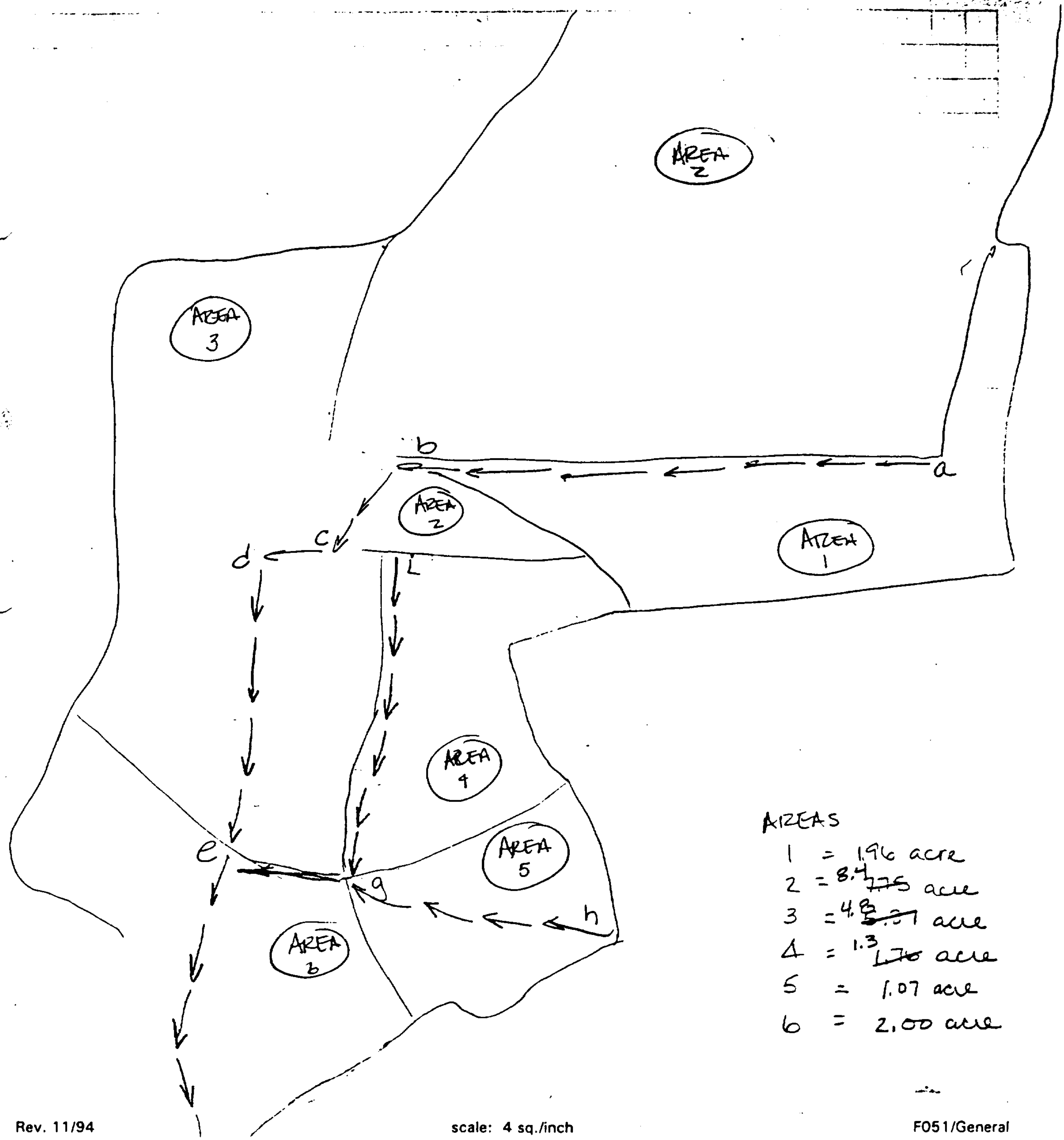
PROJECT Skinner Landfill Remedial Design

SUBJECT Western Watershed Surface Water Drainage Calculations

Prepared By MME Date 9/22

Reviewed By BER Date 10/4

Approved By ______ Date ______



AREAS

1	=	1.96 acre
2	=	8.4 ~~7.75~~ acre
3	=	4.8 ~~3.01~~ acre
4	=	1.3 ~~1.76~~ acre
5	=	1.07 acre
6	=	2.00 acre

RUST **Rust Environment & Infrastructure**

CALCULATION SHEET

PROJECT NO. 72680.500

CLIENT Skinner PRP Grap SUBJECT WESTERN WATERSHED-Surface Water Drainage Calcs

PROJECT Skinner Landfill Remedial Design

Prepared By MME Date 9/22/95

Reviewed By BER Date 10/4/95

Approved By ______ Date ______

CALCULATE RUNOFF FLOWS USING RATIONAL METHOD.

$Q = ciA$

$c = 0.44$ for vegetated clay cap

i = duration based on time of concentration, T_c

A = area in acres

Compute flow, Q

Swale a-b

Area = 1.96 (Area 1)

t_c = 14 min 5' in 450' + 16' in 300' = 10 min + 4 min

i_{100}: 6.5

$Q_{100} = 0.44(6.5)(1.96) = 5.6$ cfs

Swale b-c
c-d

Area = 10.4 (area 1 & 2)

$t_c = 10.0$ 42' in 900' = 10 min

$i_{100} = 7.5$

$Q_{100} = 0.44(7.5)(10.4) = 34.3$ cfs

Swale d-e

Area = 15.1 (Areas 1, 2, 3)

t_c = 18.0 20' in 400' + 20' in 100' + 8' in 150' + 42' in 900'
5 min 1 min 2 min 10 min

i_{100} = 5.5

Q_{100} = 0.44 (5.5)(15.1) = 36.5 cfs

Swale e-f

Area = 19.5 (1 through 6)

t_c = 25 min 18 min + 12' in 200' + 4' in 200
3 min 4 min

i_{100} = 5.0

Q_{100} = 0.44(5.0)(19.5) = 42.9 cfs

Swale h-g

Area = 1.07 (area 5)

t_c = 5.5 min 4' in 250' + 20' in 60' = 5 min + 0.4 min

i_{100} = 9.0

Q_{100} = 0.44 (9.0)(1.07) = 4.2 cfs

Swale g-i

Area = 1.3 (area 4)

t_c = 10.5 8' in 400' + 14' in 250' = 7 min + 3.5 min

i_{100} = 7.5

Q_{100} = 0.44 (7.5)(1.3) = 4.3 cfs

Swale e-g

Area = 2.37 (areas 4 and 5)

t_c = 10.5

i_{100} = 7.5

Q_{100} = 0.44 (7.5)(2.37) = 7.8 cfs

CLIENT SKINNER PRP GROUP
SUBJECT WESTERN WATERSHED SURFACE WATER DRAINAGE CALCULATIONS
PROJECT SKINNER LANDFILL REMEDIAL DESIGN

Prepared By MME Date 9/22/95
Reviewed By BER Date 10/4/95
Approved By ____ Date ____

SWALE SIZING

SWALE	Q_{100} (cfs)	CHANNEL SLOPE (ft/ft)	CHANNEL SIDE SLOPE	BOTTOM WIDTH (ft)	DEPTH (ft)/VELOCITY (fps) RETARDANCE B	C	D
a-b	5.6	0.01	3:1	4	1.4/0.5	1.0/0.9	0.9/1.3
b-c	34.3	0.05	3:1	6	1.2/3.2	0.9/4.8	0.8/5.5
c-d	34.3	Downslope flume use critical flow equation $W = 0.1763\ Q$ @ $D = 1.0$ ft $W = 6.0$ ft					
d-e	36.5	0.05	3:1	6	1.2/3.4	0.9/5.1	0.8/5.7
e-f	42.9	0.02	3:1	6	1.6/2.6	1.2/3.9	1.1/4.3
g-h	4.2	0.03	3:1	2	1.1/0.7	0.8/1.4	0.6/1.9
g-i	4.3	0.02	3:1	4	1.3/0.6	0.9/1.1	0.7/1.6
e-g	7.8	Down slope Flume use Critical Flow Equation $W = 0.4986\ Q$ @ $D = 0.5$ ft, $W = 4$ ft					

RUST ENVIRONMENT & INFRASTRUCTURE

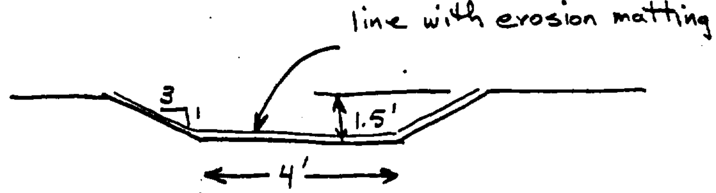
CALCULATION SHEET

PROJECT NO. 72680.500

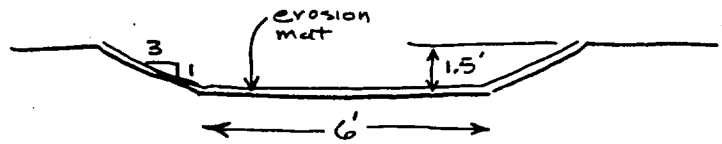
CLIENT Skinner PRP Group	SUBJECT Western Watershed	Prepared By MME	Date 9/22/95
PROJECT Skinner Landfill	Surface Water Drainage	Reviewed By BER	Date 10/4/95
Remedial Design	Calculations	Approved By	Date

Swale Shapes & Sizes

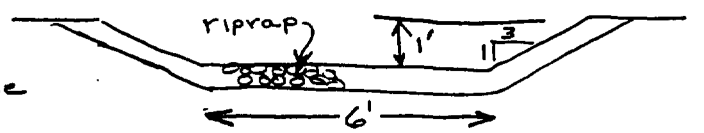
swale a-b Trapezoidal



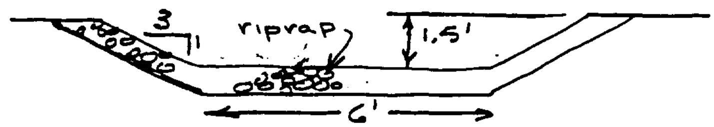
b-c Trapezoidal



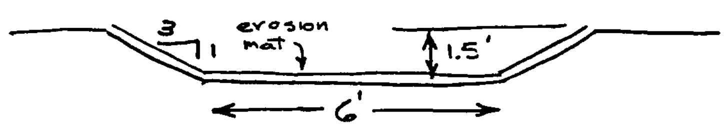
c-d trapezoidal
down slope flume



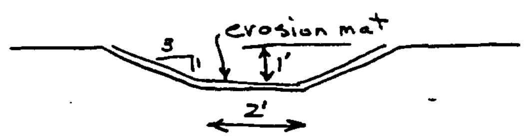
d-e trapezoidal



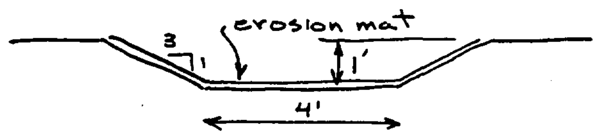
e-f Trapezoidal



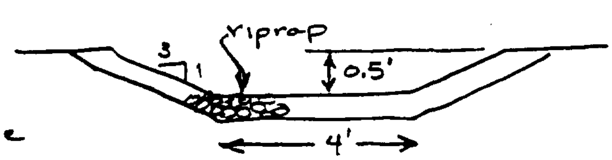
h-g trapezoidal



i-g trapezoidal



g-e trapezoidal
down slope flume



RUST **Rust Environment & Infrastructure**

CALCULATION SHEET

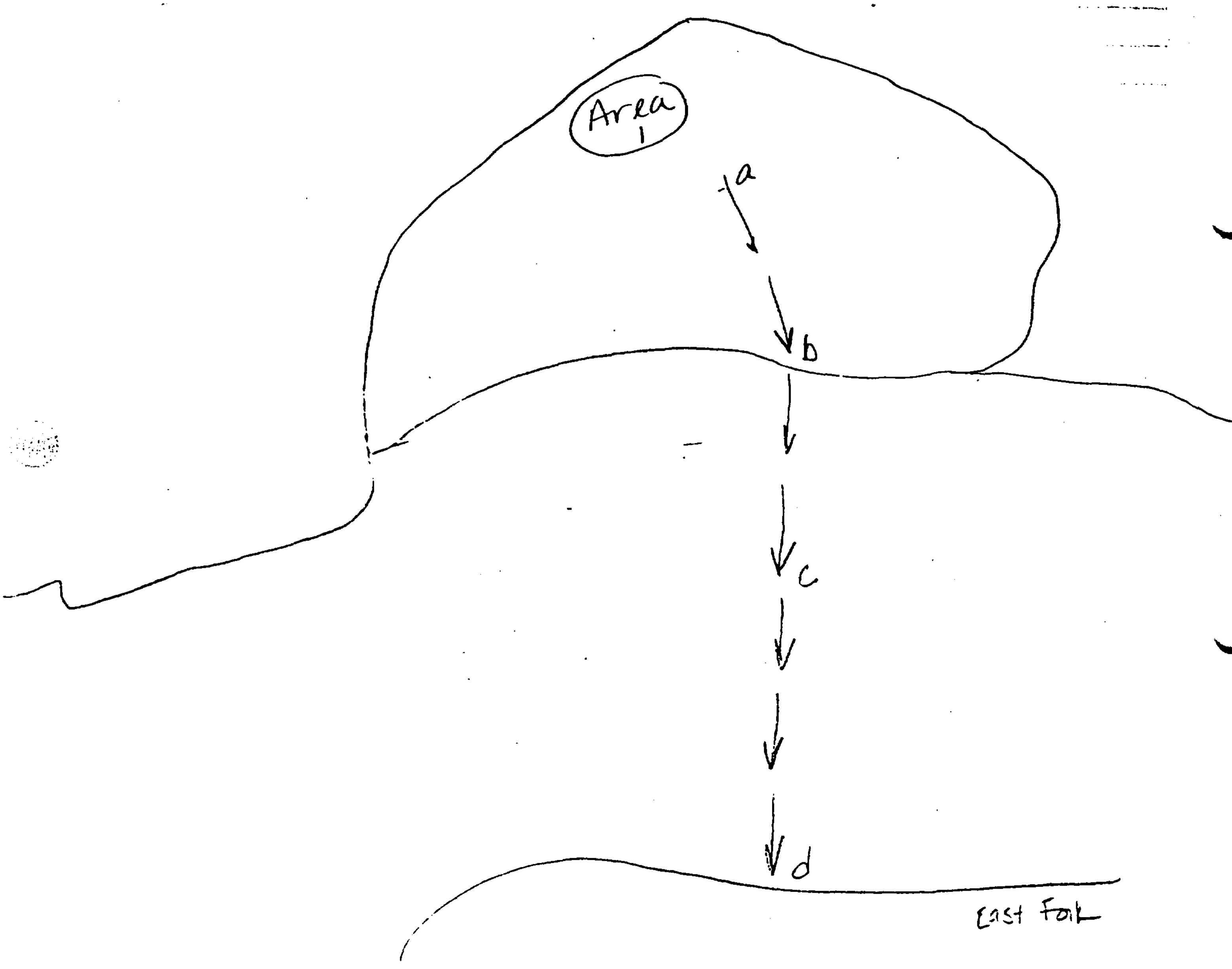
PAGE 10 OF 11

PROJECT NO. 72680.500

CLIENT SKINNER PRP GROUP SUBJECT CENTRAL WATERSHED Prepared By MME Date 9/22/95

PROJECT SKINNER LANDFILL SURFACE WATER DRAINAGE Reviewed By BER Date 10/6/95

REMEDIAL DESIGN CALCULATIONS Approved By ______ Date ______



Area 1 = 1.87 acre

CALCULATE RUNOFF FLOWS USING RATIONAL METHOD

$Q = ciA$

c = 0.44 for vegetated clay cap
i = duration based on time of concentration, t_c
A = area in acre

Compute flow, Q

Swale a-b

Area = 1.87
t_c = 4.0
i_{100} = 9.5

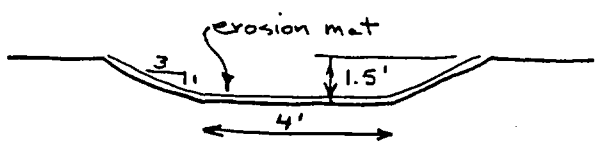
6' in 130' + 12' in 36' + 2' in 100' =
2 min — 2 min

$Q = 0.44\,(9.5)(1.87) = 7.8$ cfs

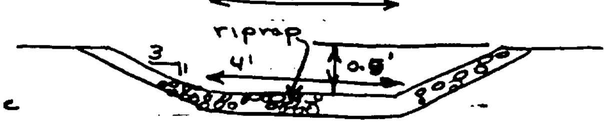
Swale a-b = Swale b-c = Swale c-d

Swale	Q_{100} (cfs)	channel slope (ft/ft)	channel side slope	Bottom width (ft)	Depth (ft) / Velocity (fps) Retardance curve B	C	D
a-b	7.8	0.01	3:1	4	1.5/0.6	1.0/1.1	0.8/1.6
b-c	7.8	downslope flume use critical flow equation $W = 0.4986\,Q$ @ $D = 0.5$ ft, $W = 4$ ft					
c-d	7.8	0.05	3:1	4	0.9/1.3	0.6/2.3	0.5/2.9

swale shape
a-b & c-d



b-c, downslope flume



Attachment A

By: BER, Date: 10/6/95

Swale Sizing Using Vegetative Retardance Curves

Set Design Data

Bottom Width (B) (ft)	8
Sideslope (Z:1)	3
Channel slope (S) (ft/ft)	0.067
Maximum Flow (Q) (cfs)	38.12
Retardance Curve (upper case)	D

Solve for Flow Depth (Y) (ft) 0.63

V1 must be equal to or close to V2

Result	Try Smaller Y
Velocity	6.137621157

Calculations

Area (A)	6.2307
Hydraulic Radius (R)	0.519897841
Velocity (V1)	6.11809267
Product (V1 * R)	3.180783169
Velocity (V2)	6.157149644
Manning's N	0.0405

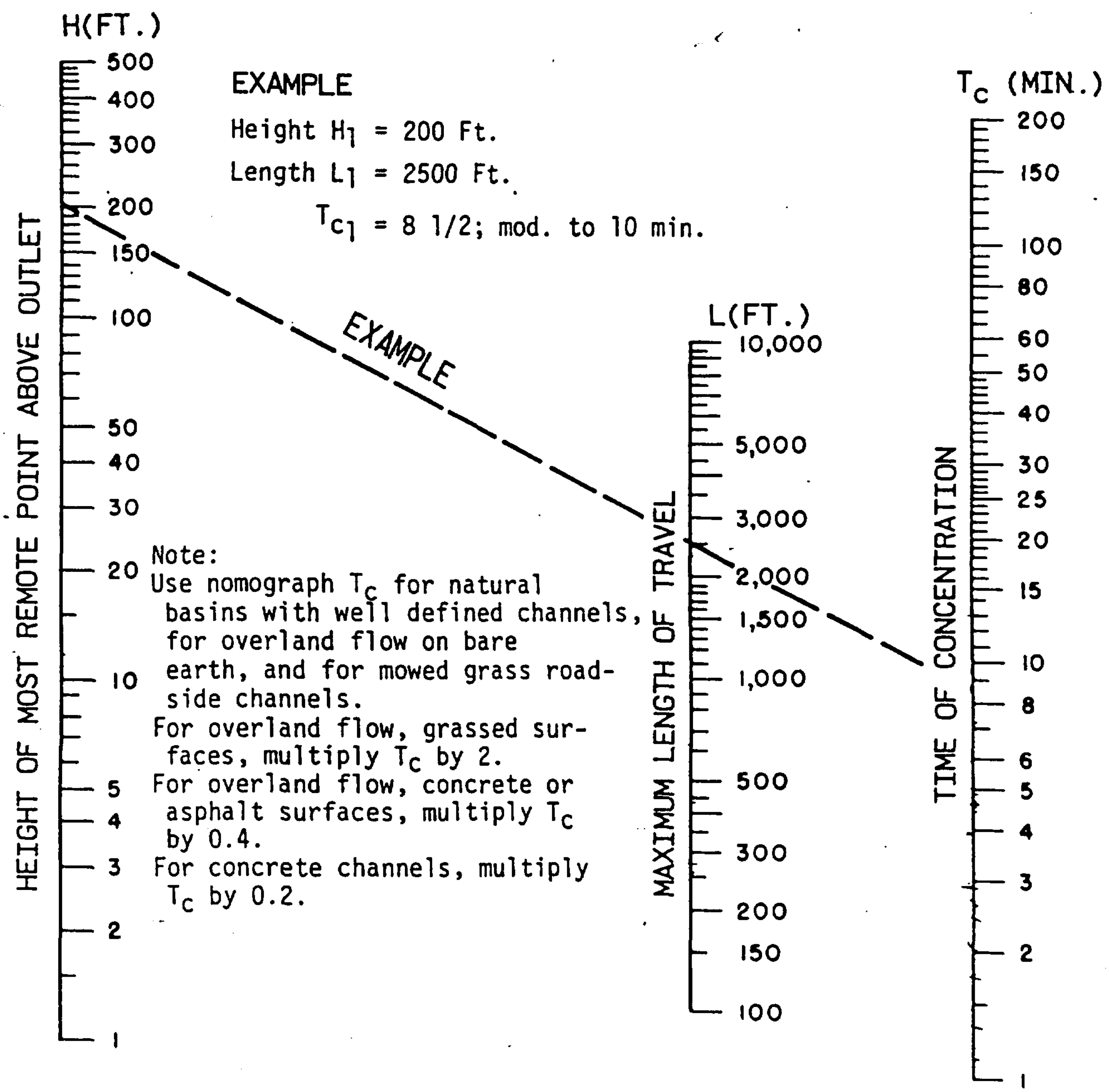
Retardance	Cover	Condition
A - Very High	Weeping Love Grass	Excellent Stand, Tall (av 30 in.)
B - High	Bermuda Grass	Good Stand, Tall (av 12 in.)
	Native Grass Mixture	Good Stand, Unmowed
	Weeping Love Grass	Good Stand, Tall (av 24 in.)
	Weeping Love Grass	Good Stand, Mowed, (av 13 in.)
C - Moderate	Crab Grass	Fair Stand, Uncut (10 to 48 in.)
	Bermuda Grass	Good Stand, Mowed (av 6 in.)
	Grass - Legume Mixture	Good Stand, Uncut (6 to 8 in.)
	Kentucky Bluegrass	Good Stand, Headed (6 to 12 in.
D - Low	Bermuda Grass	Good Stand, Cut to 2.5 in. height
	Grass - Legume Mixture	Good Stand, Uncut (4 to 5 in.)
E - Very Low	Bermuda Grass	Good Stand, Cut to 1.5 in. height

Attachment B

TIME OF CONCENTRATION OF SMALL

T_c

DRAINAGE BASINS



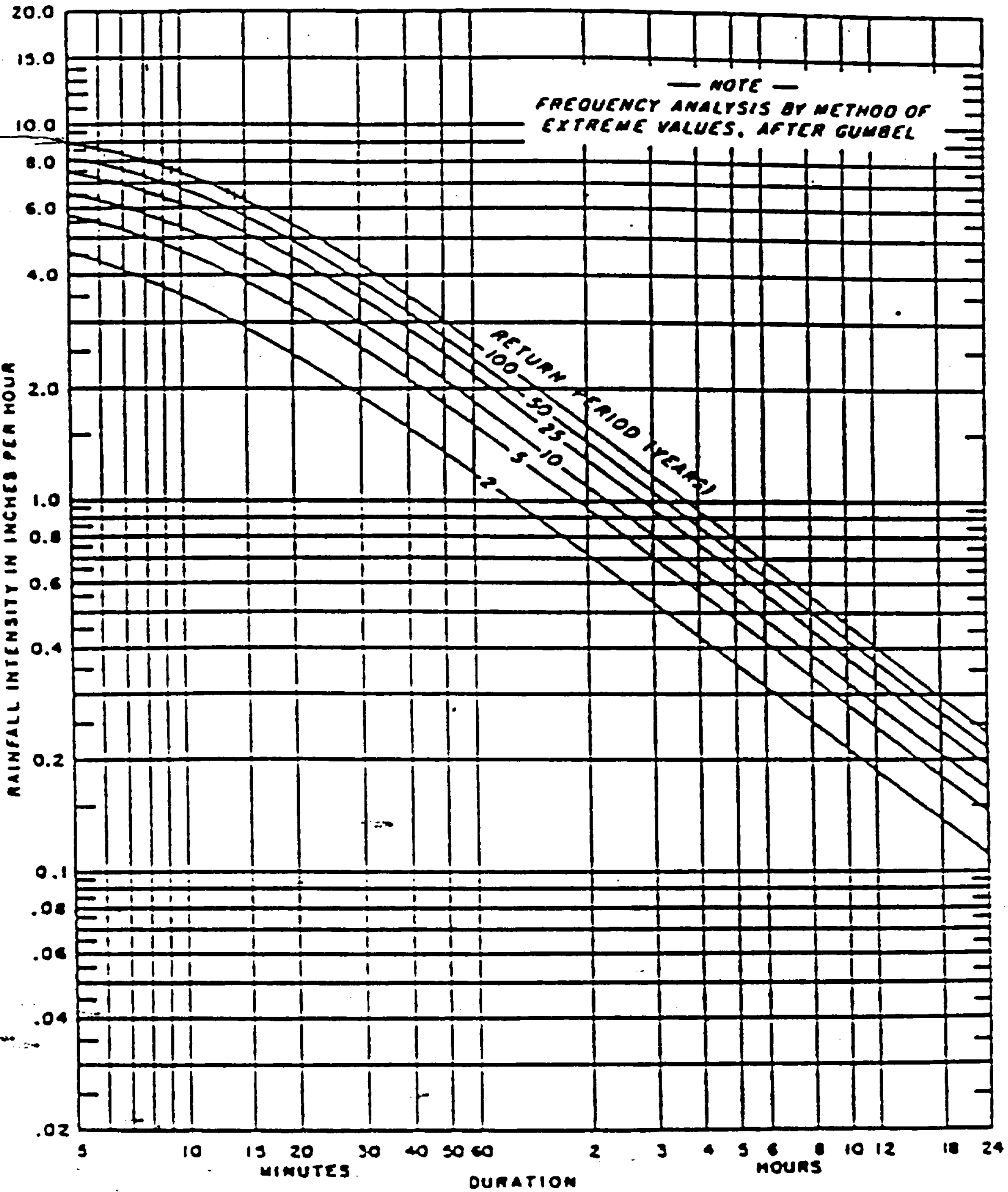
Based on study by P. Z. Kirpich,
Civil Engineering, Vol. 10, No. 6, June 1940, p.362

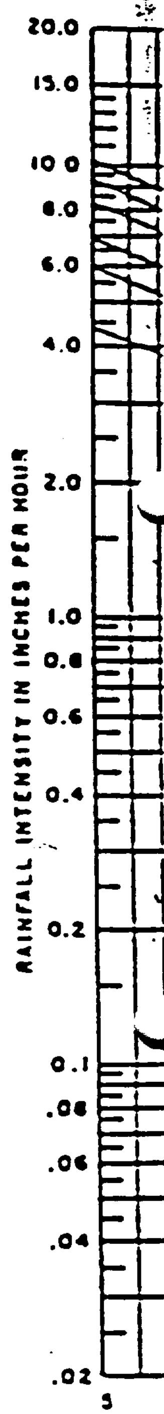
FIGURE 3

Attachment C

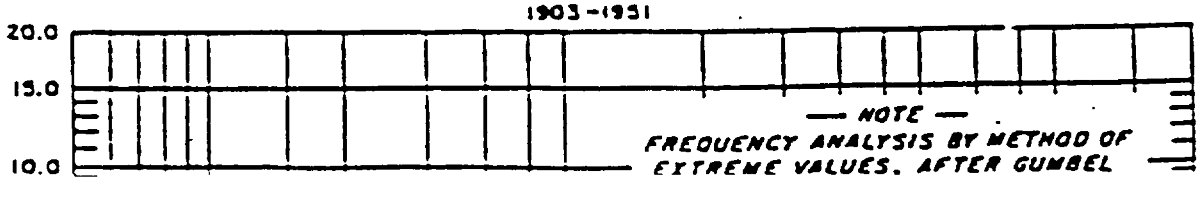
RAINFALL INTENSITY-DURATION

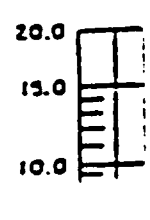
CINCINNATI, OHIO
1903–1951





COLUMBUS, OHIO
1903–1951





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CALCULATION SHEET

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RIPRAP DESIGN

FOR

BANK

OF

EXISTING

STREAM

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PROJECT NO. 72680

CLIENT Skinner SUBJECT Riprap Design Prepared By CCV Date 2/13/96

PROJECT ______ Reviewed By ______ Date ______

Approved By ______ Date ______

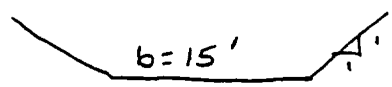
OBJECTIVE

DESIGN RIPRAP FOR BANK SIDESLOPE TO HANDLE 25 YEAR STORM FLOWS

GIVEN

- TYPICAL STREAM CROSS SECTION
  15' WIDE, 1:1 SIDESLOPE, AVG. SLOPE = 1.3%

$b/d = \frac{15}{6} = 2.5$



$d \cong 6'$ $A = (15)(6) + (6)(6) = 126\ \text{sf}$

- $P/R = WP/R = \frac{15 + 2\sqrt{(6)^2 + (6)^2}}{A/WP} = 31.9/3.95 = 8.1$

$A/P = 126/31.9 = 3.95$

- $Q_{25} = 1762$ CFS [REF # 2]

ASSUMPTIONS

- ASSUME GIVEN CROSS SECTION IS TYPICAL
- 25 YEAR DESIGN FLOW

CALCULATION SHEET

PROJECT NO. 72680

CLIENT SKINNER

SUBJECT RIPRAP DESIGN

Prepared By CCV Date 2/13/96

PROJECT ___

Reviewed By ___ Date ___

Approved By ___ Date ___

PROCEDURE

- USE METHOD AS DESCRIBED IN P. 4.12.5 IN REFERENCE # 1

REFERENCES

1) "STANDARDS FOR SOIL EROSION AND SEDIMENT CONTROL IN NEW JERSEY" NJ STATE SOIL CONSERVATION COMMITTEE, APRIL 1987

2) CALCULATED FROM "ESTIMATION OF PEAK-FREQUENCY-RELATIONS, FLOOD HYDROGRAPHS, AND VOLUME-DURATION-FREQUENCY RELATIONS OF UNGAGED SMALL URBAN STREAMS IN OHIO", OPEN-FILE REPORT 93-135, USGS, 1993

CONCLUSIONS

USE RIPRAP SIZE d_{50} = 16"

THICKNESS = 32" WITH NON-WOVEN GEOTEXTILE

RUST Rust Environment & Infrastructure

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CLIENT SKINNER SUBJECT ___

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Prepared By CCV Date 3/13/96

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Approved By ___ Date ___

CALCULATIONS

CALCULATE RIPRAP d_{50} SIZE TO BE PLACED ON BANK

P = WETTED PERIMETER R = HYDRAULIC RADIUS

$Q_{25} = 1762$ CFS $P/R = 8.1$ $R/P = 0.123$

$S_b = 1.3\% =$ AVG. SLOPE

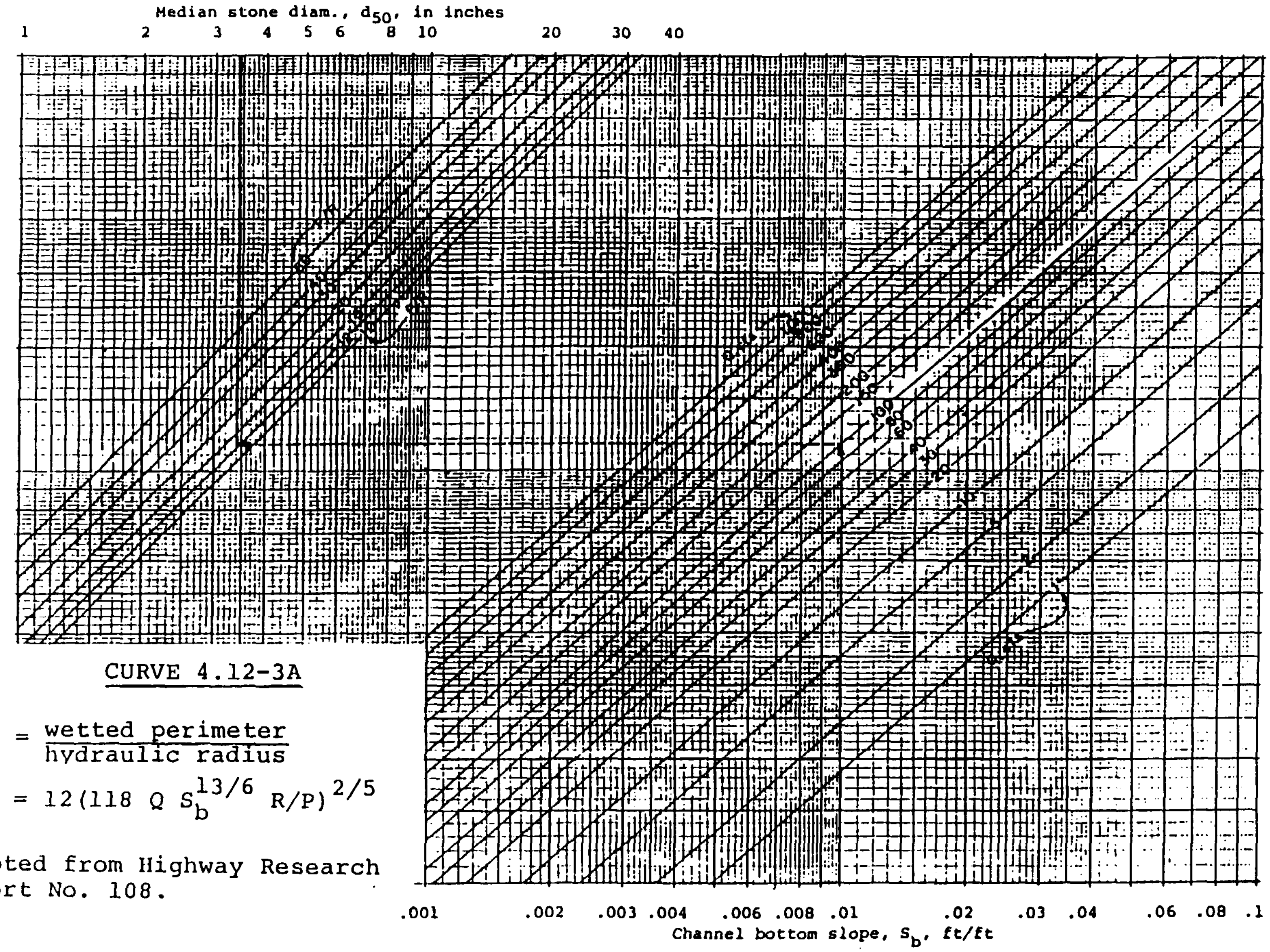
$$d_{50} = 12\left(118\,Q\,S_b^{13/6}\,R/P\right)^{2/5} = 16.1'' \quad \text{[REF\# 1]}$$

"n" value for $16'' = d_{50}$ riprap $= 0.042$

USE $d_{50} = 16''$ RIPRAP ON SIDESLOPE

EXTEND RIPRAP 3' BEYOND TOE TO BOTTOM OF CHANNEL

THICKNESS $= 2 \times d_{50} = 32''$ THICK WITH NONWOVEN GEOTEXTILE SEPARATOR



MEDIAN RIPRAP DIAMETER FOR STRAIGHT TRAPEZOIDAL CHANNELS

CURVE 4.12-3A

$$P/R = \frac{\text{wetted perimeter}}{\text{hydraulic radius}}$$

$$d_{50} = 12(118\ Q\ S_b^{13/6}\ R/P)^{2/5}$$

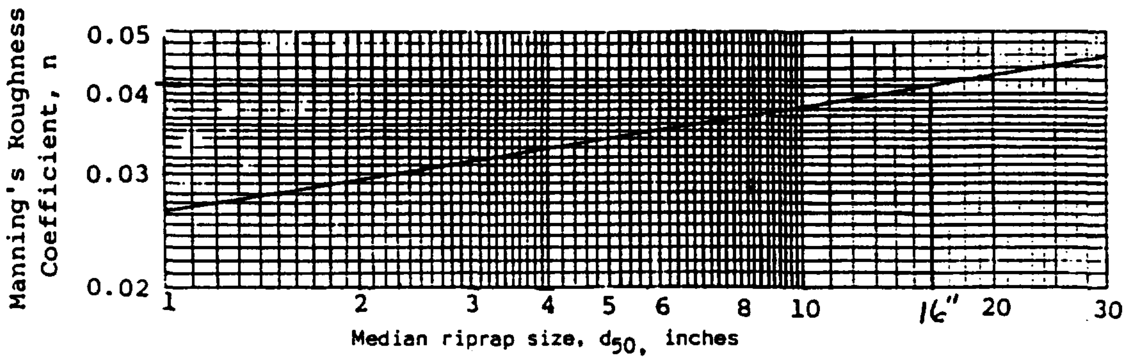
Adapted from Highway Research Report No. 108.

[REF #1]

This procedure is based on the assumption that the channel is already designed and the remaining problem is to determine the riprap size that would be stable in the channel. The designer would first determine the channel dimensions by the use of Manning's equation. The "n" value for use in Manning's equation is obtained by estimating a riprap size and then determining the corresponding "n" value for the riprapped channel from $n = 0.0395\ d_{50}^{\ 1/6}$, where d_{50} is in feet, or by using Curve 4.12-1, below, where d_{50} is in inches.

CURVE 4.12-1

MANNING'S "n" FOR RIPRAP-LINED CHANNELS



When the channel dimensions are known, the riprap can be designed (or an already completed design may be checked) as follows:

Trapezoidal Channels

1. Calculate the b/d ratio and enter Curve 4.12-2 to find the P/R ratio.

2. Enter Curve 4.12-3 with S_b, Q, and P/R to find median riprap diameter, d_{50}, for straight channels.

3. Enter Curve 4.12-1 to find the actual "n" value corresponding to the d_{50} from step 2. If the estimated and actual "n" values do not reasonably agree, another trial must be made.

4. For channels with bends, calculate the ratio B_s/R_o, where B_s is the channel surface width and R_o is the radius of the bend. Enter Curve 4.12-4 and find the bend factor, F_B. Multiply the d_{50} for straight channels by the bend factor to determine riprap size to be used in bends. If the d_{50} for the bend is less than 1.1 times the d_{50} for the straight channel, then the size for straight channel may be used in the bend; otherwise, the larger stone size calculated for the bend shall be used. The riprap shall extend across the full channel section and shall extend upstream and downstream from the ends of the curve a distance equal to five times the bottom width.

5. Enter Curve 4.12-5 to determine maximum stable side slope of riprap surface. In Curve 4.12-5, the side slope is established so that the riprap on the side slope is as stable as that on the bottom. If for any reason it is desirable to make the side slopes steeper than what is given by Curve 4.12-5, the size of the riprap can be increased and the side slopes made steeper by using the following procedures:

   a. Compute d_{50} and maximum stable side slope as above.

   b. Enter Curve 4.12-6 with the computed side slope to determine K for that side slope.

   c. Enter Curve 4.12-6 with the desired side slope to determine K'.

   d. Compute riprap size for desired slope by the formula:

$$d_{50}' = d_{50}\frac{K}{K'}$$

[REF #1]

6. Maximum side slopes, 2:1.

BUTLER COUN
HAMILTON COUN

ELEVATION REFERENCE MARKS

REFERENCE MARKS	ELEVATION FEET (NGVD)	DESCRIPTION OF LOCATION
RM 64	585.76	Chiseled square on west side of northwest abutment of Cresentville Road bridge over Mill Creek.
RM 65	590.86	Top of north I-beam of west guardrail on Windisch Road bridge over Mill Creek.
RM 66	609.46	Top of east end of corrugated storm pipe located about 5480 feet east of the intersection of Mulhauser Road and State Route 747.
RM 67	595.37	Top of east bolt on outside wooden track protector at northeast end of intersection of Conrail Railroad and Rialto Road.
RM 68	595.15	Chiseled square in northeast corner of northeast abutment of Rialto Road bridge over Mill Creek.
RM 69	598.54	A chiseled square at northwest corner of northwest abutment of culvert under Conrail, 55 feet northwest of State Route 747 at Mill Creek.

NATIONAL FLOOD I... ...RANCE PROGR...

FIRM

FLOOD INSURANCE RATE MA

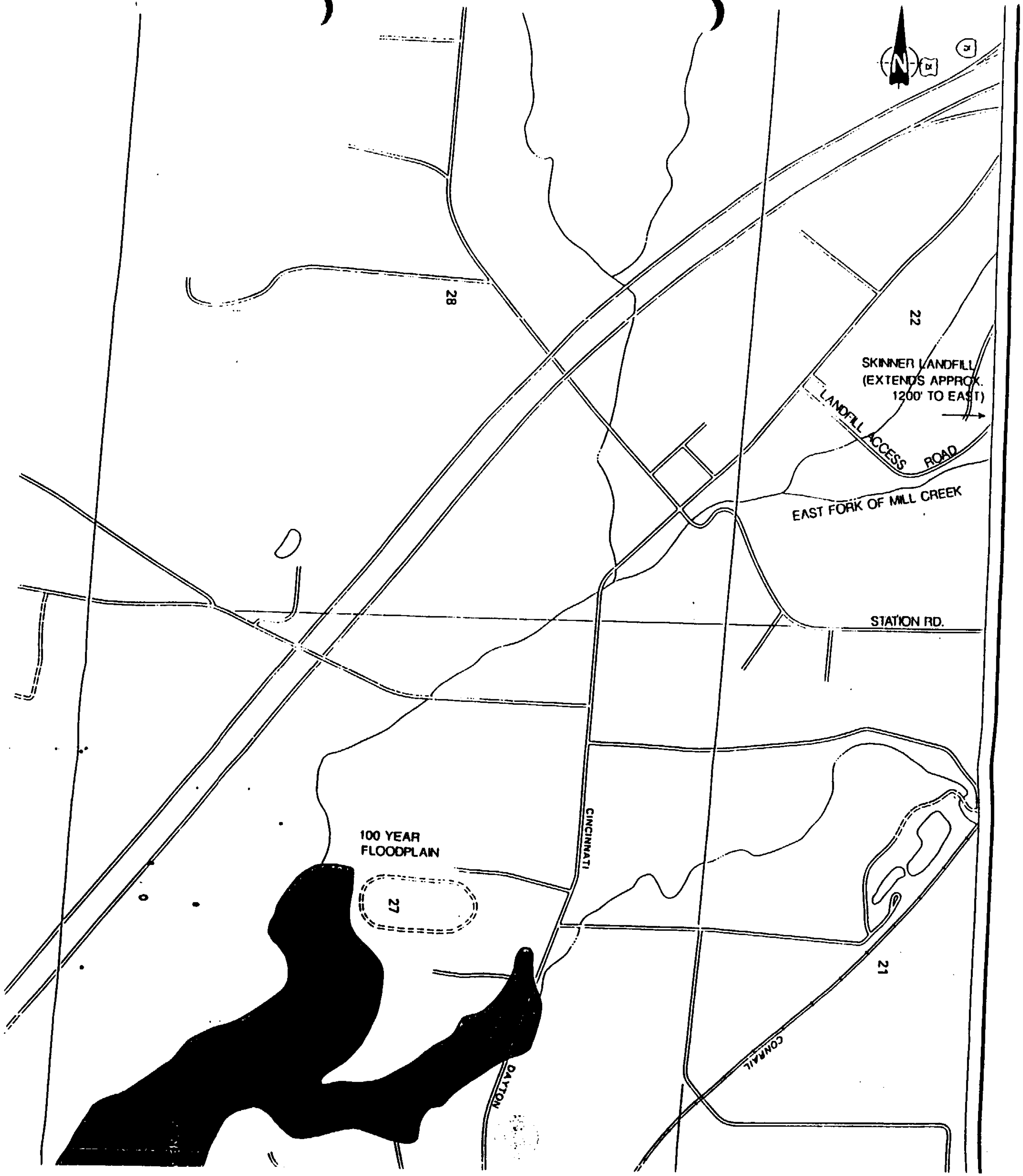
COUNTY OF
BUTLER,
OHIO
(UNINCORPORATED AREA

PANEL 50 OF 155
(SEE MAP INDEX FOR PANELS NOT PRINTE

COMMUNITY-PANEL NUMBE
390037 0050

EFFECTIVE DATE
NOVEMBER 4, 198

federal emergency management agen
federal insurance administration


SKINNER LANDFILL
(EXTENDS APPROX.
1200' TO EAST)
LANDFILL ACCESS ROAD
EAST FORK OF MILL CREEK
STATION RD.
22
28
21
27
100 YEAR
FLOODPLAIN
CINCINNATI
DAYTON
CONRAIL
N

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CALCULATION SHEET

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PEAK FLOW IN
UNGAGED STREAM
USING MULTIPLE -
REGRESSION
ANALYSIS

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CALCULATION SHEET

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PROJECT NO. 72680

CLIENT SKINNER

SUBJECT STREAM FLOW

Prepared By CCV Date 2/13/96

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Reviewed By ______ Date ______

Approved By ______ Date ______

OBJECTIVE

OBTAIN 100YR & 25YR FLOW USING MULTIPLE-REGRESSION ANALYSIS.

GIVEN

- DRAINAGE AREA IS APPROX 2.88 SQ MILES (USE 3.0 SQ. MILES) (SEE SHEET 4)
- USGS MAP (GLENDALE, OH & MASON, OH QUADS)
- ANNUAL RAINFALL DATA FOR SOUTHEAST BUTLER COUNTY = 41 INCHES [REF #1] (SEE SHEET 5)

ASSUMPTIONS

- ASSUME DRAINAGE DIRECTIONS IN URBAN AREAS (SUBDIVISIONS)

Rev. 11/94 scale: 4 sq./inch F051/General

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CALCULATION SHEET

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CLIENT SKINNER SUBJECT STREAM FLOW Prepared By CCV Date 2/13/96

PROJECT ___ Reviewed By ___ Date ___

Approved By ___ Date ___

PROCEDURE

1) USE USGS MULTIPLE-REGRESSION ANALYSIS FOR URBAN STREAMS IN OHIO TO CALCULATE 100 YEAR PEAK FLOW & 25 YR PEAK FLOW

REFERENCES

1) "ESTIMATION OF PEAK-FREQUENCY RELATIONS, FLOOD HYDROGRAPHS, AND VOLUME-DURATION-FREQUENCY RELATIONS OF UNGAGED SMALL URBAN STREAMS IN OHIO", OPEN-FILE REPORT 93-135, USGS, 1993

CONCLUSION

Q_{100} = 2619 CFS

Q_{25} = 1762 CFS

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CLIENT Skinner

SUBJECT

Prepared By CCV Date 3/13/96

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CALCULATIONS

A = DRAINAGE AREA = 2.88 SQ MILES
(USE 3 SQ MILES)

P = AVERAGE ANNUAL PRECIPITATION = 41 INCHES
[REF #1] SEE SHEET 5

BDF = BASIN DEVELOPMENT FACTOR = 7
SEE SHEET 6 FOR DETERMINATION

100 YR MULTIPLE REGRESSION EQUATION [REF #1]

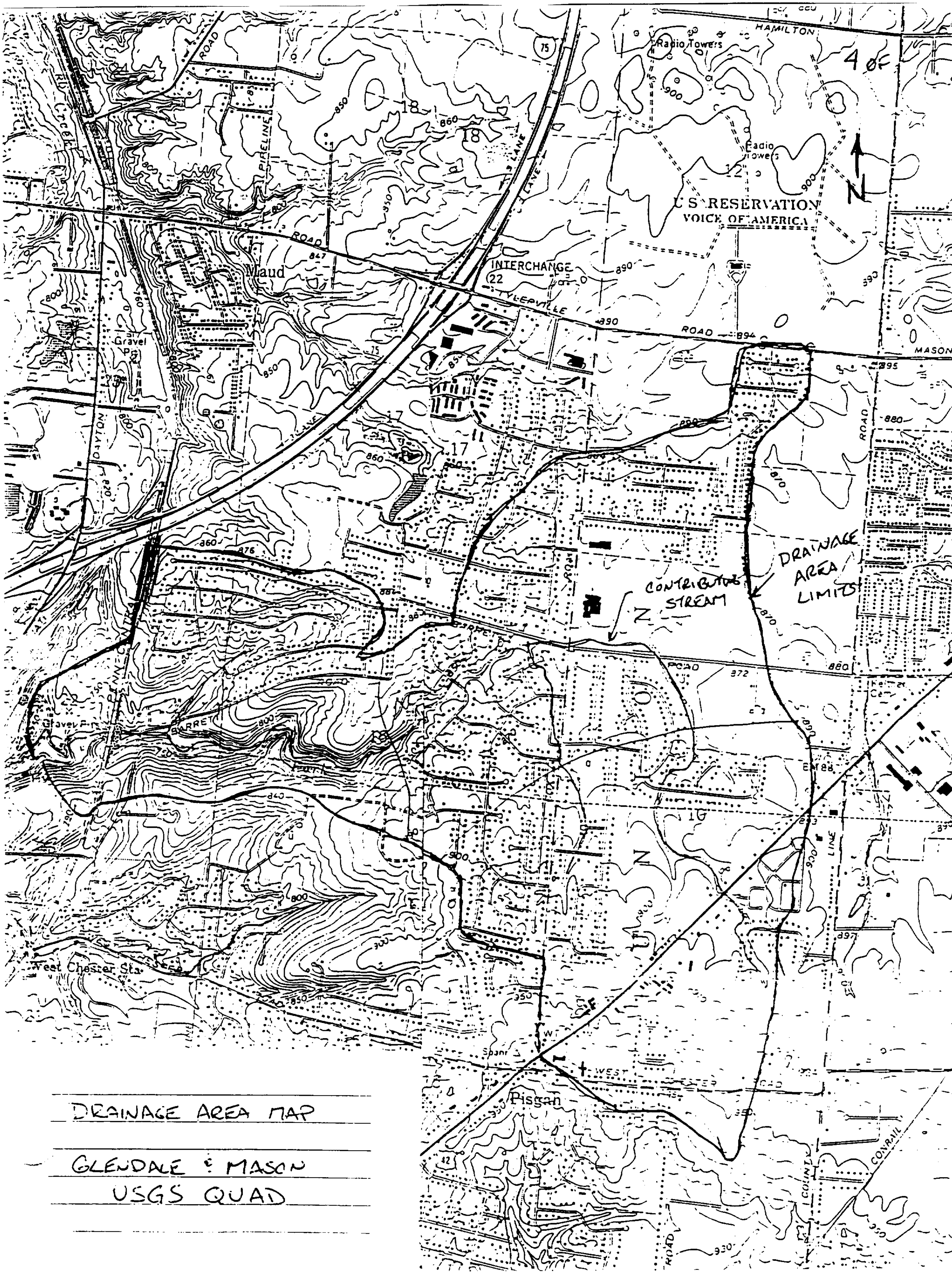
$$UQ_{100} = 321\,(A)^{0.79}\,(P-30)^{0.76}\,(13-BDF)^{-0.33}$$

$$UQ_{100} = (764.6)\quad(6.2)\quad(0.55) = \underline{2619}\ \text{CFS}$$

25 YR MULTIPLE REGRESSION EQUATION

$$UQ_{25} = 265(A)^{0.76}\,(P-30)^{0.72}\,(13-BDF)^{-0.37}$$

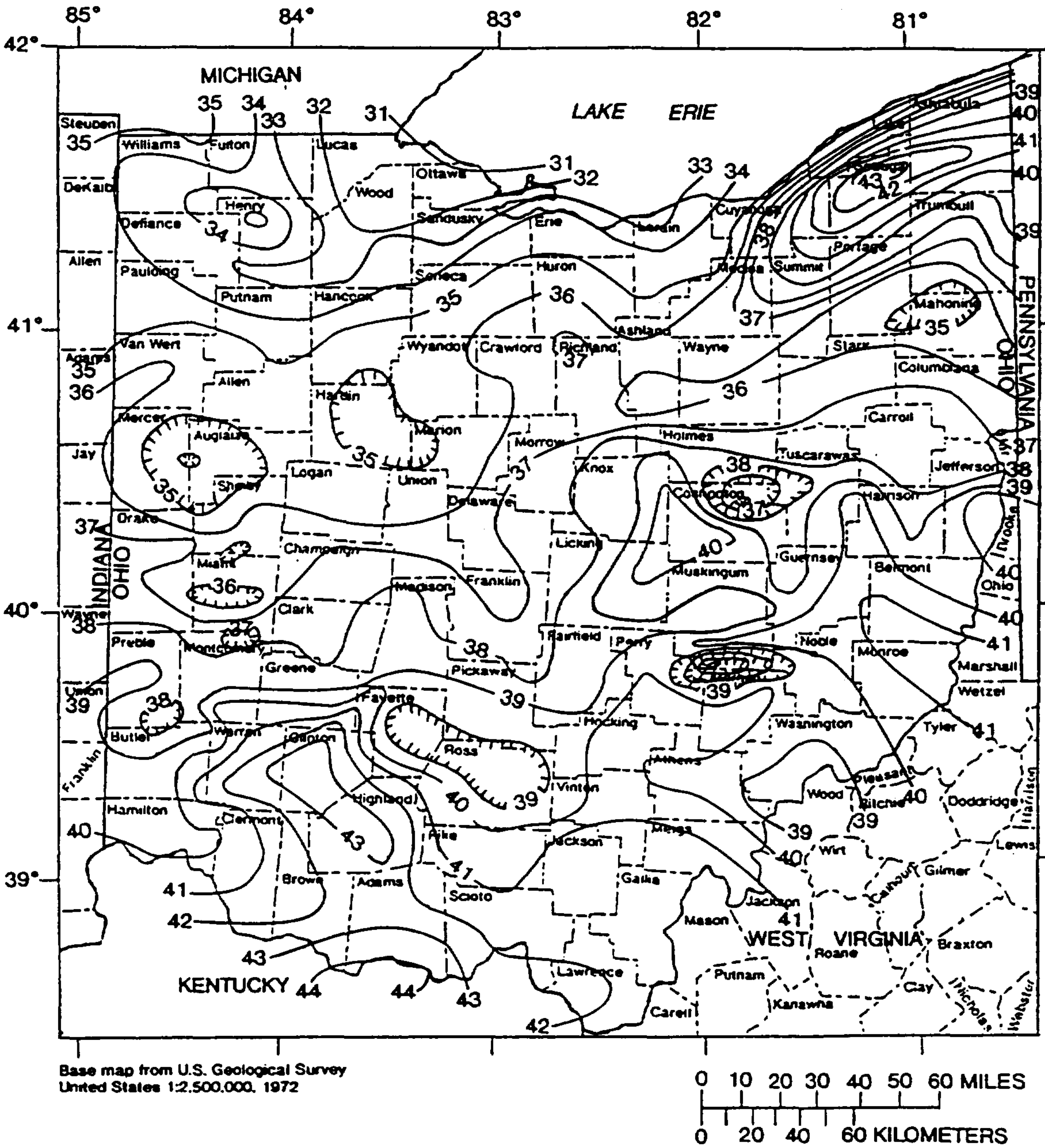
$$(610.7)\quad(5.6)\quad(0.52) = \underline{1762}\ \text{CFS}$$



DRAINAGE AREA MAP

GLENDALE & MASON
USGS QUAD

5 of



EXPLANATION

—34 LINE OF EQUAL AVERAGE ANNUAL PRECIPITATION--Hachured lines enclose areas of lesser precipitation. Interval is one-inch

Figure 8.--Average annual precipitation for Ohio for 1931-1980 (modified from Harstine, 1991).

BASIN-DEVELOPMENT FACTOR

FIELD NOTES

STATION NAME: East Fork of Mill Creek

LOCATION: West Chester, Butler County I.D. NUMBER:

EVALUATOR: DATE: 2/13/96

ASPECT	THIRD	CODE	REMARKS
Channel Improvements	Lower	0	
	Middle	1	
	Upper	0	
Channel Linings	Lower	0	
	Middle	0	
	Upper	0	
Storm Sewers	Lower	1	
	Middle	1	
	Upper	1	
Curb & Gutter Streets	Lower	1	
	Middle	1	
	Upper	1	

BDF = 7

Figure 10.--*Field note sheet for evaluating basin-development factor (BDF).*

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100 YEAR FLOOD

ELEVATIONS

ESTIMATION

Rust Environment & Infrastructure

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PURPOSE

- ESTIMATE 100 YR FLOOD ELEVATIONS IN CRITICAL SECTIONS OF MILL CREEK BY USING MANNING'S EQUATION

GIVEN

- Q_{100} = 2619 CFS (MULTIPLE REGRESSION ANALYSIS) [REF #2]
- STREAM HAS ROCKS AND COBBLES IN BED
- SLOPE ≅ 1.3%
- TOPOGRAPHY FOR CROSS SECTION DATA

ASSUMPTION

- ASSUME MANNING'S n = 0.040 BASED ON STREAM CHARACTERISTICS (SEE SHEET 15) [REF #3]

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PROCEDURES

- DRAW UP CROSS SECTIONS OF STREAM (LOCATION OF CROSS SECTIONS ARE SHOWN ON SHEET 14) (CROSS SECTIONS ARE LOCATED WITH CALCULATIONS)

- USE MANNING'S EQUATION TO SOLVE FOR STREAM DIMENSIONS ($AR^{2/3}$) BASED ON 100 YR FLOW

- ASSUME DEPTHS IN CROSS SECTIONS AND CALCULATED ACTUAL STREAM FLOW AREA AND WETTED PERIMETER FOR EACH CROSS SECTION USING PLANIMETER AND SCALES

- BY INTERPOLATION, CALCULATE THE DEPTH WHICH MATCHES THE 100 YR FLOW CHARACTERISTICS

- SHOW 100 YEAR FLOW ELEVATIONS ON CROSS SECTIONS AND PLOT 100 YEAR FLOOD LIMIT ON PLAN VIEW

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REFERENCES

1) TOPOGRAPHY PROVIDED BY AEROMETRIC ENGINEERING

2) "ESTIMATION OF PEAK FREQUENCY RELATIONS, FLOOD HYDROGRAPHS, AND VOLUME - DURATION - FREQUENCY RELATIONS OF UNGAGED SMALL URBAN STREAMS IN OHIO", OPEN-FILE REPORT 93-135, USGS, 1993

3) "DATA BOOK FOR CIVIL ENGINEERS - DESIGN" EDWIN E SEELYE, REVISED 1960

CONCLUSION

THE 100 YEAR FLOOD ELEVATION DOES NOT IMPACT THE PROPOSED LANDFILL. THE 100 YR FLOOD ELEVATIONS LIMITS PLOT OUTSIDE THE FENCED - IN AREA.

100 YR FLOOD ELEVATIONS FOR EACH CROSS - SECTION

CROSS - SECTION	ELEVATION
A - A'	679.9
B - B'	685.2
C - C'	687.1
D - D'	691.1
E - E'	694.7

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CALCULATIONS

- USE MANNING'S EQUATION (SOLVE FOR $AR^{2/3}$)

$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

$$\frac{Qn}{1.486 S^{1/2}} = AR^{2/3} = \frac{(2619)(.04)}{1.486\ (.013)^{1/2}} = 618.3$$

FOR EACH CROSS SECTION
SOLVE FOR DEPTH
BY INTERPOLATION

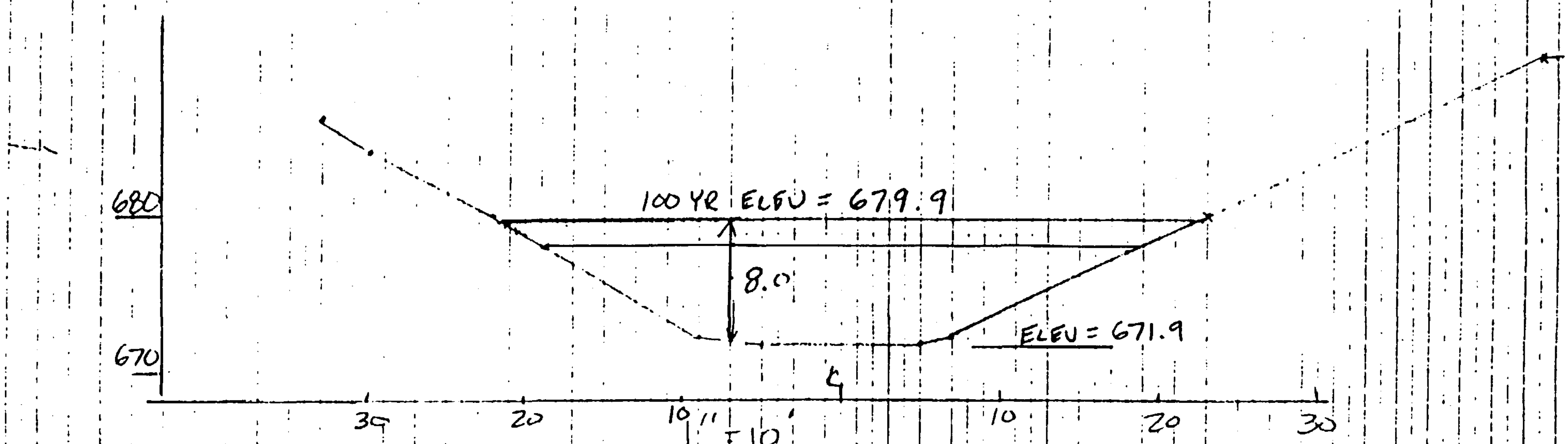
* CROSS - SECTION A (SEE SHEET 5)

(FT) DEPTH	(SF) A	(FT) WP	R	$R^{2/3}$	$AR^{2/3}$
8	~~244~~ 222	47	4.7	2.82	~~731~~ 625.0
6	~~160~~ 140	39	3.6	2.34	328.2

$$\frac{625.0 - 328.2}{618.3 - 328.2} = \frac{8-6}{x-6}$$

$X = 8.0'$ DEPTH

∴ 100 YR FLOW STAYS IN BANKS



(LOOKING UPSTREAM)

SECTION A-A'

9

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CROSS SECTION B
(SEE SHEET 1)

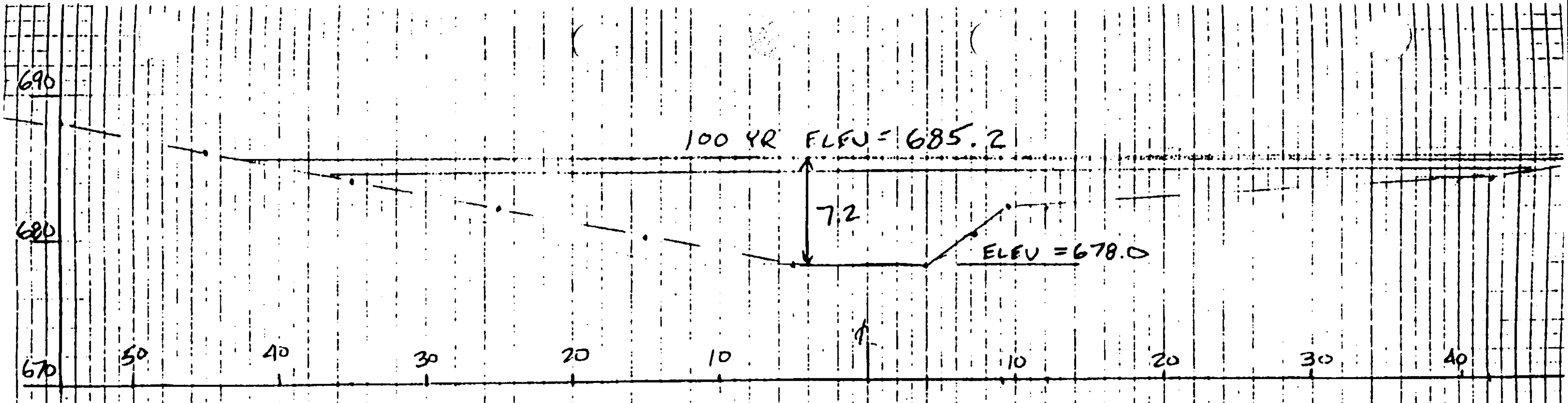
$AR^{2/3} = 618.3$

DEPTH	A	WP	R	$R^{2/3}$	$AR^{2/3}$
6.5	226	83	2.72	1.95	440.7
7	269	90	2.99	2.07	558.2
7.5	313	96	3.26	2.20	688.2

$$\frac{688.2 - 558.2}{618.3 - 558.2} = \frac{7.5 - 7}{x - 7}$$

$$x = 7.2$$

∴ 100 YEAR FLOW STAYS BEHIND FENCE



SCALE 1" = 10'
(LOOKING UPSTREAM)
SECTION B-B'

RUST **Rust Environment & Infrastructure**

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CROSS - SECTION C
(SEE SHEET 9)

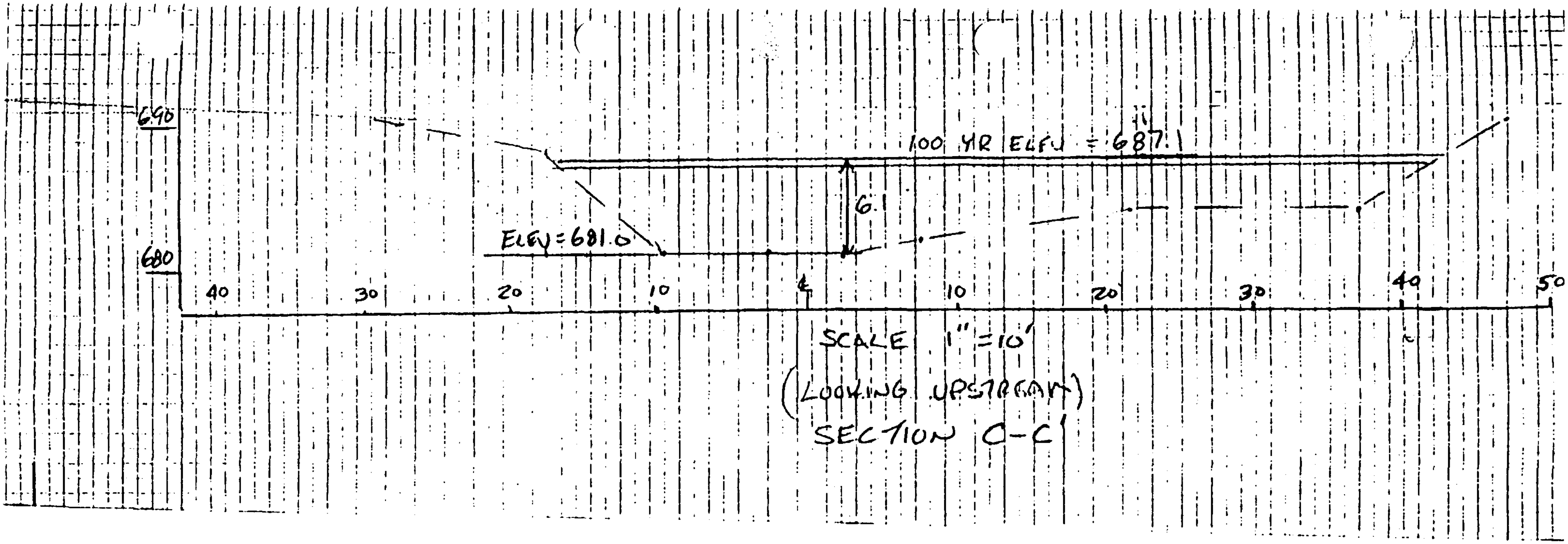
$AR^{2/3} = 618.3$

DEPTH	A	WP	R	$R^{2/3}$	$AR^{2/3}$
6	239	62	3.85	2.46	587.6
6.5	269	64	4.20	2.60	700.6

$$\frac{700.6 - 587.6}{618.3 - 587.6} = \frac{6.5 - 6}{x - 6}$$

$$x = 6.1'$$

∴ 100 YR FLOW STAYS IN BANKS


690
680
100 YR ELEV = 687.1
6.1
ELEV = 681.0
40
30
20
10
℄
10
20
30
40
50
SCALE 1" = 10'
(LOOKING UPSTREAM)
SECTION C-C'

RUST **Rust Environment & Infrastructure**

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CROSS SECTION D

(SEE SHEET 11)

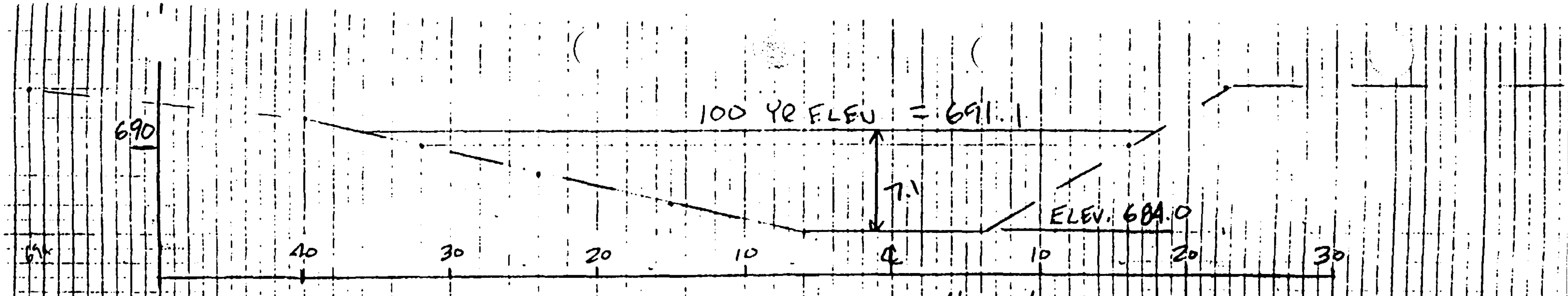
$AR^{2/3} = 618.3$

DEPTH	A	WP	R	$R^{2/3}$	$AR^{2/3}$
6	180	50.5	3.56	2.33	420.0
7	231	56	4.13	2.57	594.1
7.5	258	59	4.37	2.67	689.9

$$\frac{689.9-594.1}{618.3-594.1} = \frac{7.5-7}{X-7}$$

$$X = 7.1$$

∴ 100 YEAR FLOWS STAYS BEHIND FENCE



SCALE 1" = 10'
(LOOKING UPSTREAM)
SECTION D-D'

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Approved By ______ Date ______

CROSS SECTION E
(SEE SHEET 13)

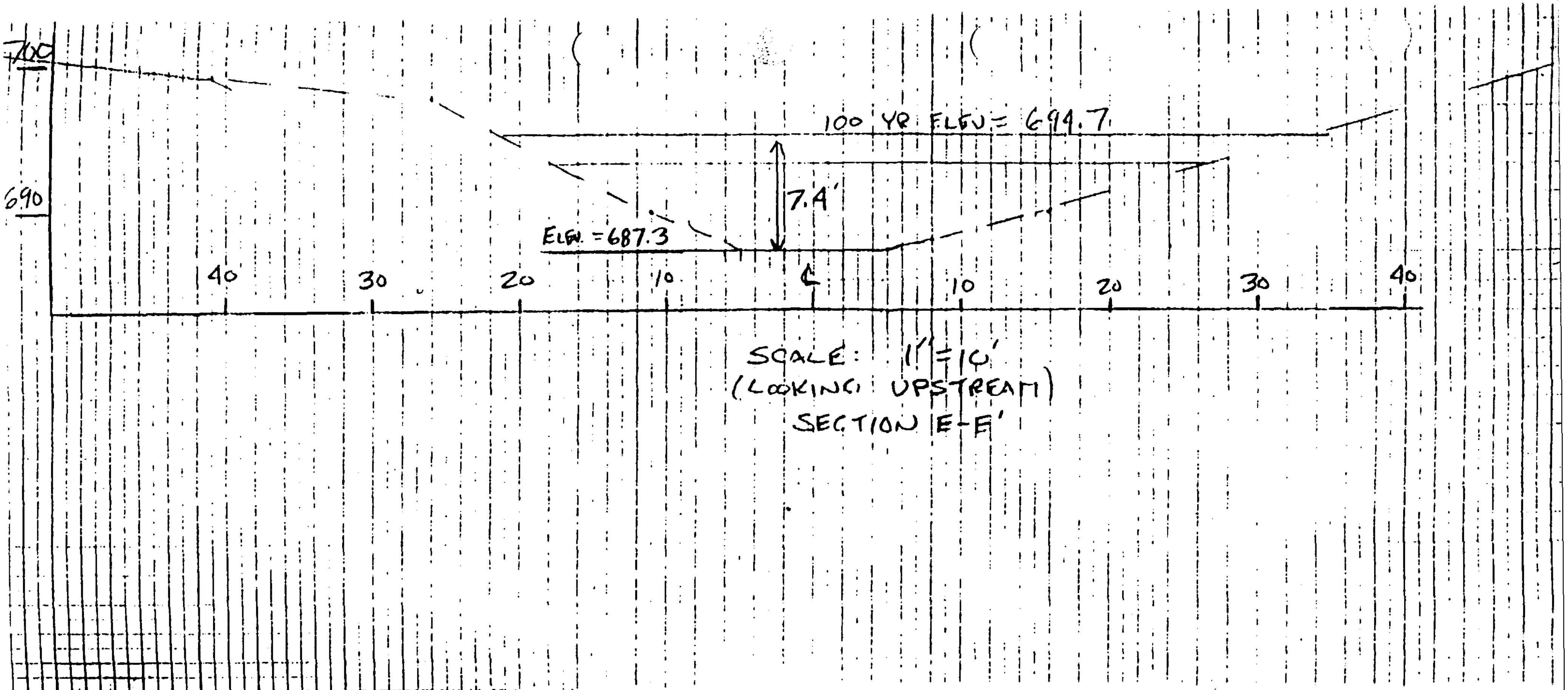
$AR^{2/3} = 618.3$

DEPTH	A	WP	R	$R^{2/3}$	$AR^{2/3}$
6	165	47	3.51	2.31	381.1
7	212	53	4.00	2.52	534.2
8	269	59	4.56	2.75	739.6

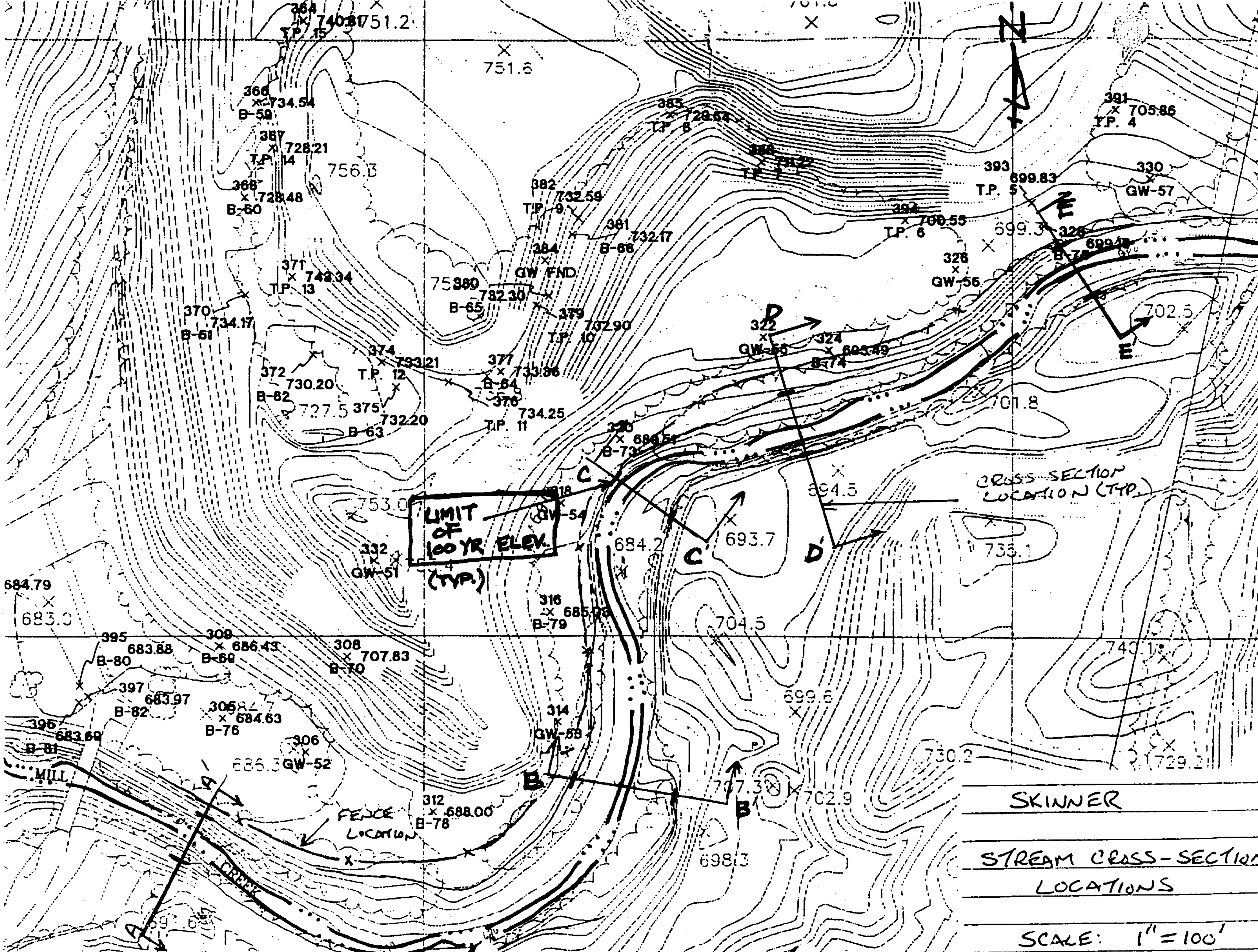
$$\frac{739.6 - 534.2}{618.3 - 534.2} = \frac{8-7}{x-7}$$

$$x = 7.4$$

$\therefore$ 100 YR FLOW STAYS IN BANKS



700
690
100 YR ELEV = 694.7
7.4'
ELEV. = 687.3
40
30
20
10
℄
10
20
30
40
SCALE: 1" = 10'
(LOOKING UPSTREAM)
SECTION E-E'



SKINNER

STREAM CROSS-SECTION LOCATIONS

SCALE: 1" = 100'

DRAINAGE & SEWERAGE-HYDRAULIC COMPUTATIONS-I

TABLE A-VALUES OF n, TO BE USED WITH KUTTER OR MANNING FORMULAS.†

SURFACE	CONDITION			
	BEST	GOOD	FAIR	BAD
Uncoated cast-iron pipe	0.012	0.013	0.014	0.015
Coated cast-iron pipe	0.011	0.012*	0.013*	
Commercial wrought-iron pipe, black	0.012	0.013	0.014	0.015
Commercial wrought-iron pipe, galvanized	0.013	0.014	0.015	0.017
Smooth brass and glass pipe	0.009	0.010	0.011	0.013
Smooth lockbar and welded OD pipe	0.010	0.011*	0.013*	
Riveted and spiral steel pipe	0.013	0.015*	0.017*	
Vitrified sewer pipe	{0.010 0.011}	0.013*	0.015	0.017
Common clay drainage tile	0.011	0.012*	0.014*	0.017
Glazed brickwork	0.011	0.012	0.013*	0.015
Brick in cement mortar, brick sewers	0.012	0.013	0.015*	0.017
Neat cement surfaces	0.010	0.011	0.012	0.013
Cement-mortar surfaces	0.011	0.012	0.013*	0.015
Concrete pipe	0.012	0.013	0.015*	0.016
Wood-stave pipe	0.010	0.011	0.012	0.013
Plank flumes:				
Planed	0.010	0.012*	0.013	0.014
Unplaned	0.011	0.013*	0.014	0.015
With battens	0.012	0.015*	0.016	
Concrete-lined channels	0.012	0.014*	0.016*	0.018
Cement-rubble surface	0.017	0.020	0.025	0.030
Dry rubble surface	0.025	0.030	0.033	0.035
Dressed ashlar surface	0.013	0.014	0.015	0.017
Semicircular metal flumes, smooth	0.011	0.012	0.013	0.015
Semicircular metal flumes, corrugated	0.0225	0.025	0.0275	0.030
Canals and ditches:				
Earth, straight and uniform	0.017	0.020	0.0225*	0.025
Rock cuts, smooth and uniform	0.025	0.030	0.033*	0.035
Rock cuts, jagged and irregular	0.035	0.040	0.045	
Winding sluggish canals	0.0225	0.025*	0.0275	0.030
Dredged earth channels	0.025	0.0275*	0.030	0.033
Canals with rough stony beds, weeds on earth banks	0.025	0.030	0.035*	0.040
Earth bottom, rubble sides	0.028	0.030*	0.033*	0.035
Natural stream channels:				
1. Clean, straight bank, full stage, no rifts or deep pools	0.025	0.0275	0.030	0.033
2. Same as (1), but some weeds and stones	0.030	0.033	0.035	0.040
3. Winding, some pools and shoals, clean	0.033	0.035	0.040	0.045
4. Same as (3), lower stages, more ineffective slope and sections	0.040	0.045	0.050	0.055
5. Same as (3), some weeds and stones	0.035	0.040	0.045	0.050
6. Same as (4), stony sections	0.045	0.050	0.055	0.060
7. Sluggish river reaches, rather weedy or with very deep pools	0.050	0.060	0.070	0.080
8. Very weedy reaches	0.075	0.100	0.125	0.150

Note: Asbestos-Cement Pipe (Transite) use 0.010.

* *Values commonly used in designing.*

HAMILTON COUN

ELEVATION REFERENCE MARKS

REFERENCE MARKS	ELEVATION FEET (NGVD)	DESCRIPTION OF LOCATION
RM 64	585.76	Chiseled square on west side of northwest abutment of Cresentville Road bridge over Mill Creek.
RM 65	590.86	Top of north I–beam of west guardrail on Windisch Road bridge over Mill Creek.
RM 66	609.46	Top of east end of corrugated storm pipe located about 5480 feet east of the intersection of Mulhauser Road and State Route 747.
RM 67	595.37	Top of east bolt on outside wooden track protector at northeast end of intersection of Conrail Railroad and Rialto Road.
RM 68	595.15	Chiseled square in northeast corner of northeast abutment of Rialto Road bridge over Mill Creek.
RM 69	598.54	A chiseled square at northwest corner of northwest abutment of culvert under Conrail, 55 feet northwest of State Route 747 at Mill Creek.

FIRM
FLOOD INSURANCE RATE MA

COUNTY OF
BUTLER,
OHIO
(UNINCORPORATED ARE

PANEL 50 OF 155
(SEE MAP INDEX FOR PANELS NOT PRINT

COMMUNITY-PANEL NUMB
390037 0050

EFFECTIVE DAT
NOVEMBER 4, 19

federal emergency management age
federal insurance administration

N
28
22
SKINNER LANDFILL
(EXTENDS APPROX.
1200' TO EAST)
LANDFILL ACCESS ROAD
EAST FORK OF MILL CREEK
STATION RD.
CINCINNATI
100 YEAR
FLOODPLAIN
27
21
CONRAIL
DAYTON

RUST **Rust Environment & Infrastructure**

CALCULATION SHEET

PAGE ___ OF ___

PROJECT NO. 72680

CLIENT SKINNER

SUBJECT ______

Prepared By CCV Date 2/13/96

PROJECT ______

Reviewed By ______ Date ______

Approved By ______ Date ______

PEAK FLOW IN UNGAGED STREAM USING MULTIPLE - REGRESSION ANALYSIS

Rust Environment & Infrastructure

CALCULATION SHEET

PROJECT NO. 72680

CLIENT SKINNER

SUBJECT STREAM FLOW

Prepared By CCV Date 2/13/96

PROJECT ______

Reviewed By ______ Date ______

Approved By ______ Date ______

OBJECTIVE

OBTAIN 100YR & 25YR FLOW USING MULTIPLE-REGRESSION ANALYSIS.

GIVEN

- DRAINAGE AREA IS APPROX 2.88 SQ MILES (USE 3.0 SQ. MILES) (SEE SHEET 4)
- USGS MAP (GLENDALE, OH & MASON, OH QUADS)
- ANNUAL RAINFALL DATA FOR SOUTHEAST BUTLER COUNTY = 41 INCHES [REF #1] (SEE SHEET 5)

ASSUMPTIONS

- ASSUME DRAINAGE DIRECTIONS IN URBAN AREAS (SUBDIVISIONS)

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CALCULATION SHEET

PROJECT NO. 72680

CLIENT SKINNER SUBJECT STREAM FLOW

Prepared By CCV Date 2/13/96

PROJECT ___ Reviewed By ___ Date ___

Approved By ___ Date ___

PROCEDURE

1) USE USGS MULTIPLE-REGRESSION ANALYSIS FOR URBAN STREAMS IN OHIO TO CALCULATE 100 YEAR PEAK FLOW & 25 YR PEAK FLOW

REFERENCES

1) "ESTIMATION OF PEAK-FREQUENCY RELATIONS, FLOOD HYDROGRAPHS, AND VOLUME-DURATION-FREQUENCY RELATIONS OF UNGAGED SMALL URBAN STREAMS IN OHIO", OPEN-FILE REPORT 93-135, USGS, 1993

CONCLUSION

Q_{100} = 2619 cfs

Q_{25} = 1762 cfs

Rust Environment & Infrastructure

CALCULATION SHEET

PAGE 3 OF ___
PROJECT NO. 72680
CLIENT Skinner
SUBJECT ___
Prepared By CCV Date 3/13/96
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Approved By ___ Date ___

CALCULATIONS

A = DRAINAGE AREA = 2.88 SQ MILES
(USE 3 SQ MILES)

P = AVERAGE ANNUAL PRECIPITATION = 41 INCHES
[REF #1] SEE SHEET 5

BDF = BASIN DEVELOPMENT FACTOR = 7
SEE SHEET 6 FOR DETERMINATION

100 YR MULTIPLE REGRESSION EQUATION [REF #1]

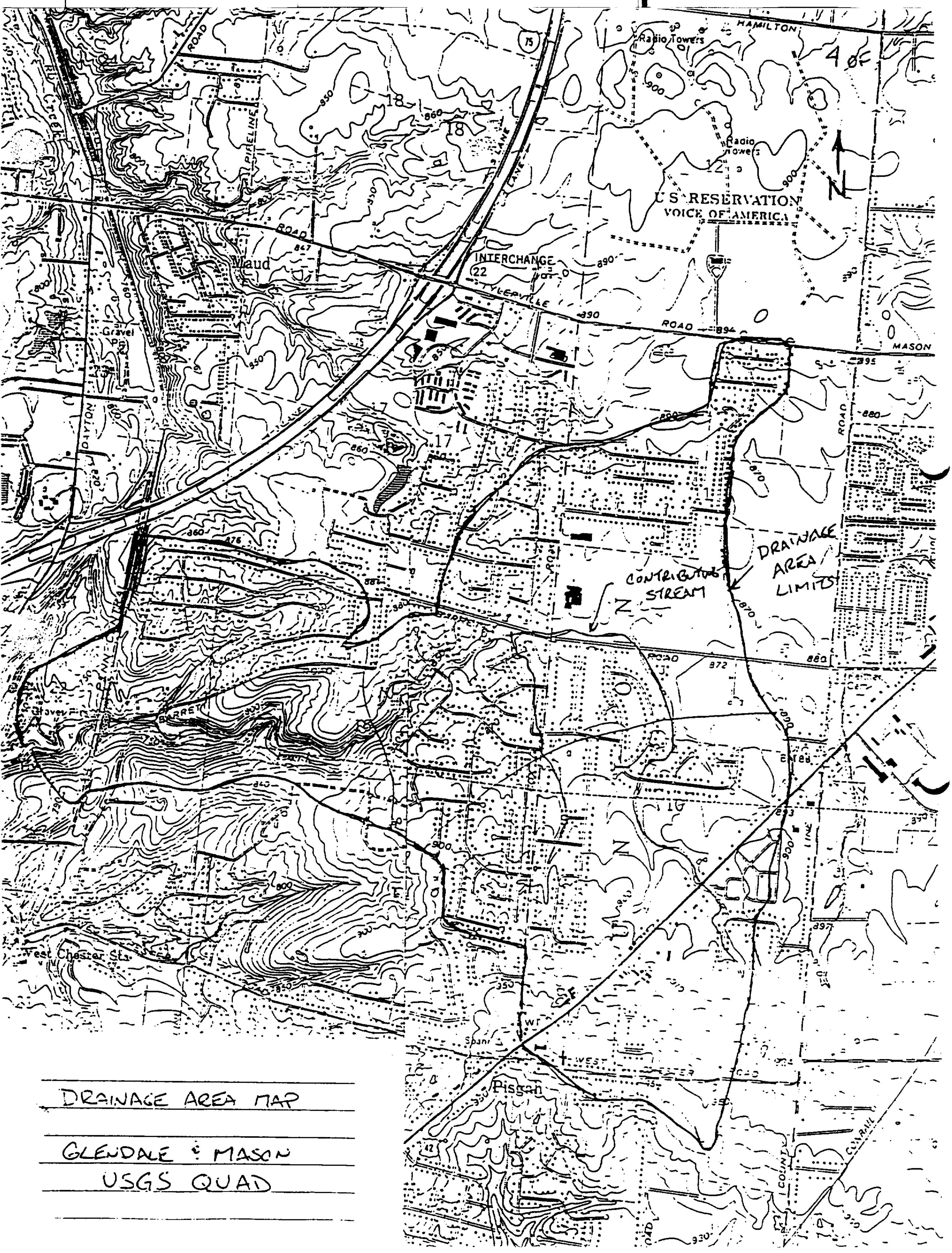
$$UQ_{100} = 321\,(A)^{0.79}\,(P-30)^{0.76}\,(13-BDF)^{-0.33}$$

$$UQ_{100} = (764.6)\quad(6.2)\quad(0.55) = \underline{2619}\ \text{CFS}$$

25 YR MULTIPLE REGRESSION EQUATION

$$UQ_{25} = 265(A)^{0.76}\,(P-30)^{0.72}\,(13-BDF)^{-0.37}$$

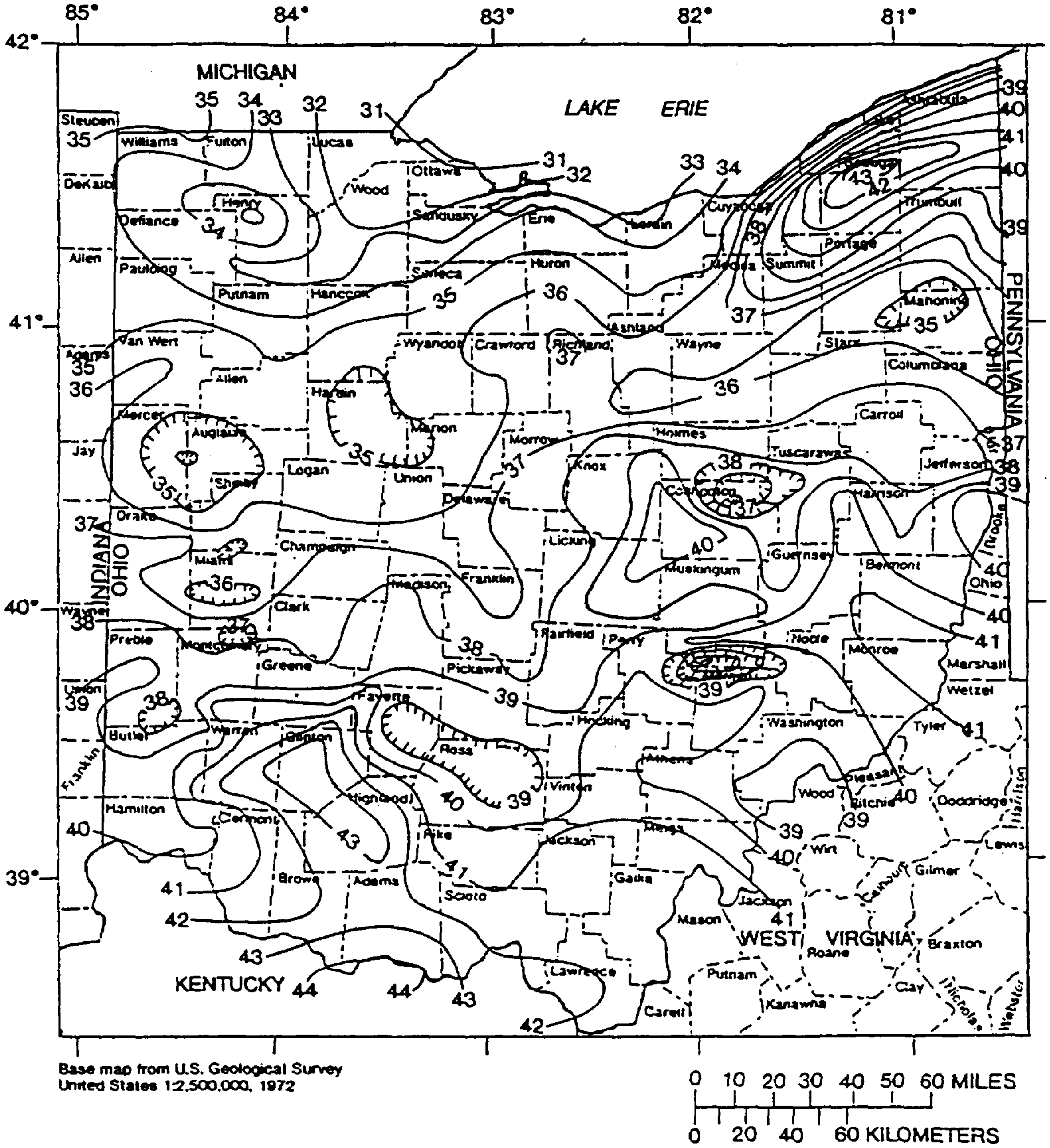
$$(610.7)\quad(5.6)\quad(0.52) = \underline{1762}\ \text{CFS}$$



DRAINAGE AREA MAP

GLENDALE & MASON
USGS QUAD

5 of



EXPLANATION

—34 LINE OF EQUAL AVERAGE ANNUAL PRECIPITATION--Hachured lines enclose areas of lesser precipitation. Interval is one-inch

Figure 8.--Average annual precipitation for Ohio for 1931-1980 (modified from Harstine, 1991).

BASIN-DEVELOPMENT FACTOR

FIELD NOTES

STATION NAME: East Fork of Mill Creek

LOCATION: West Chester, Butler County

I.D. NUMBER:

EVALUATOR:

DATE: 2/13/96

ASPECT	THIRD	CODE	REMARKS
Channel Improvements	Lower	0	
	Middle	1	
	Upper	0	
Channel Linings	Lower	0	
	Middle	0	
	Upper	0	
Storm Sewers	Lower	1	
	Middle	1	
	Upper	1	
Curb & Gutter Streets	Lower	1	
	Middle	1	
	Upper	1	

BDF = 7

Figure 10.--Field note sheet for evaluating basin-development factor (BDF).

CALCULATION SHEET

PAGE ___ OF ___

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100 YEAR FLOOD

ELEVATIONS

ESTIMATION

RUST **Rust Environment & Infrastructure**

CALCULATION SHEET

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CLIENT SKINNER SUBJECT ______

Prepared By CCV Date 2/14/96

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Reviewed By ______ Date ______

Approved By ______ Date ______

PURPOSE

- ESTIMATE 100 YR FLOOD ELEVATIONS IN CRITICAL SECTIONS OF MILL CREEK BY USING MANNING'S EQUATION

GIVEN

- Q_{100} = 2619 CFS (MULTIPLE REGRESSION ANALYSIS) [REF #2]
- STREAM HAS ROCKS AND COBBLES IN BED
- SLOPE ≅ 1.3%
- TOPOGRAPHY FOR CROSS SECTION DATA

ASSUMPTION

- ASSUME MANNING'S n = 0.040 BASED ON STREAM CHARACTERISTICS (SEE SHEET 15) [REF #3]

RUST Rust Environment & Infrastructure

CALCULATION SHEET

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PROCEDURES

- DRAW UP CROSS SECTIONS OF STREAM (LOCATION OF CROSS SECTIONS ARE SHOWN ON SHEET 14) (CROSS SECTIONS ARE LOCATED WITH CALCULATIONS)

- USE MANNING'S EQUATION TO SOLVE FOR STREAM DIMENSIONS ($AR^{2/3}$) BASED ON 100 YR FLOW

- ASSUME DEPTHS IN CROSS SECTIONS AND CALCULATED ACTUAL STREAM FLOW AREA AND WETTED PERIMETER FOR EACH CROSS SECTION USING PLANIMETER AND SCALES

- BY INTERPOLATION, CALCULATE THE DEPTH WHICH MATCHES THE 100 YR FLOW CHARACTERISTICS

- SHOW 100 YEAR FLOW ELEVATIONS ON CROSS SECTIONS AND PLOT 100 YEAR FLOOD LIMIT ON PLAN VIEW

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CALCULATION SHEET

PROJECT NO. 72680

CLIENT SKINNER

SUBJECT

Prepared By CCV Date 3/14/95

PROJECT

Reviewed By ___ Date ___

Approved By ___ Date ___

REFERENCES

1) TOPOGRAPHY PROVIDED BY AEROMETRIC ENGINEERING

2) "ESTIMATION OF PEAK FREQUENCY RELATIONS, FLOOD HYDROGRAPHS, AND VOLUME - DURATION - FREQUENCY RELATIONS OF UNGAGED SMALL URBAN STREAMS IN OHIO", OPEN-FILE REPORT 93-135, USGS, 1993

3) "DATA BOOK FOR CIVIL ENGINEERS - DESIGN", EDWIN E SEELYE, REVISED 1960

CONCLUSION

THE 100 YEAR FLOOD ELEVATION DOES NOT IMPACT THE PROPOSED LANDFILL. THE 100 YR FLOOD ELEVATIONS LIMITS PLOT OUTSIDE THE FENCED-IN AREA.

100 YR FLOOD ELEVATIONS FOR EACH CROSS-SECTION

CROSS-SECTION	ELEVATION
A-A'	679.9
B-B'	685.2
C-C'	687.1
D-D'	691.1
E-E'	694.7

RUST Rust Environment & Infrastructure

CALCULATION SHEET

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CLIENT SKINNER

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Prepared By CCV Date 2/14/96

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Approved By ___ Date ___

CALCULATIONS

- USE MANNING'S EQUATION (SOLVE FOR $AR^{2/3}$)

$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

$$\frac{Qn}{1.486 S^{1/2}} = AR^{2/3} = \frac{(2619)(.04)}{1.486 \ (.013)^{1/2}} = 618.3$$

FOR EACH CROSS SECTION
SOLVE FOR DEPTH
BY INTERPOLATION

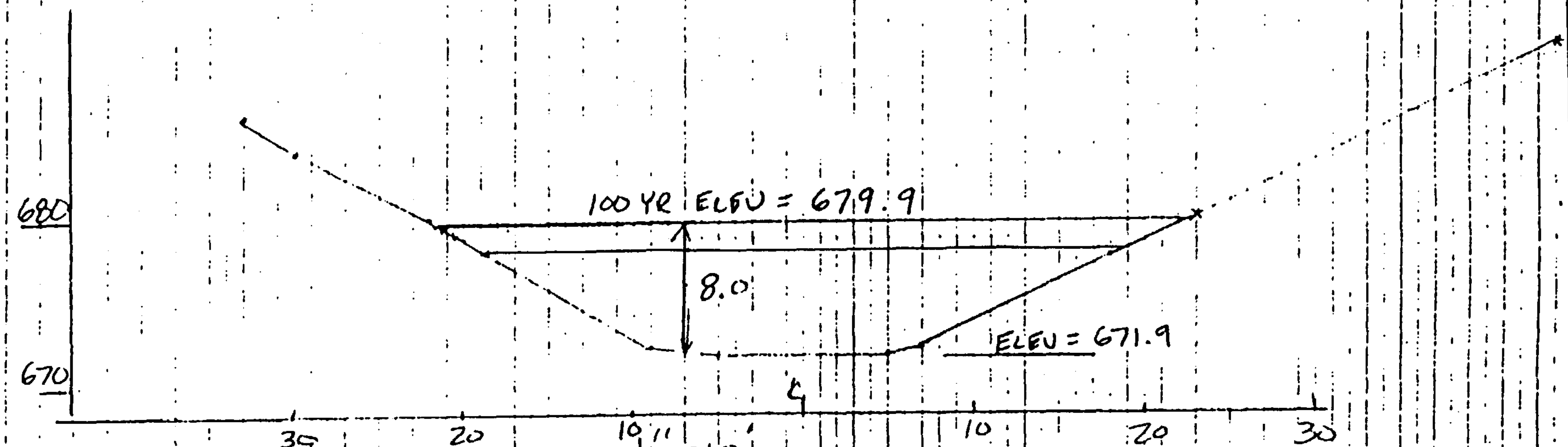
* CROSS - SECTION A (SEE SHEET 5)

(FT) DEPTH	(SF) A	(FT) WP	R	$R^{2/3}$	$AR^{2/3}$
8	~~244~~ 222	47	4.7	2.82	~~731~~ 625.0
6	~~150~~ 140	39	3.6	2.34	328.2

$$\frac{625.0 - 328.2}{618.3 - 328.2} = \frac{8-6}{X-6}$$

$X = 8.0'$ DEPTH

∴ 100 YR FLOW STAYS IN BANKS



1" = 10'

(LOOKING UPSTREAM)

SECTION A-A'

RUST Rust Environment & Infrastructure

CALCULATION SHEET

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PROJECT ___

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CROSS SECTION B
(SEE SHEET 1)

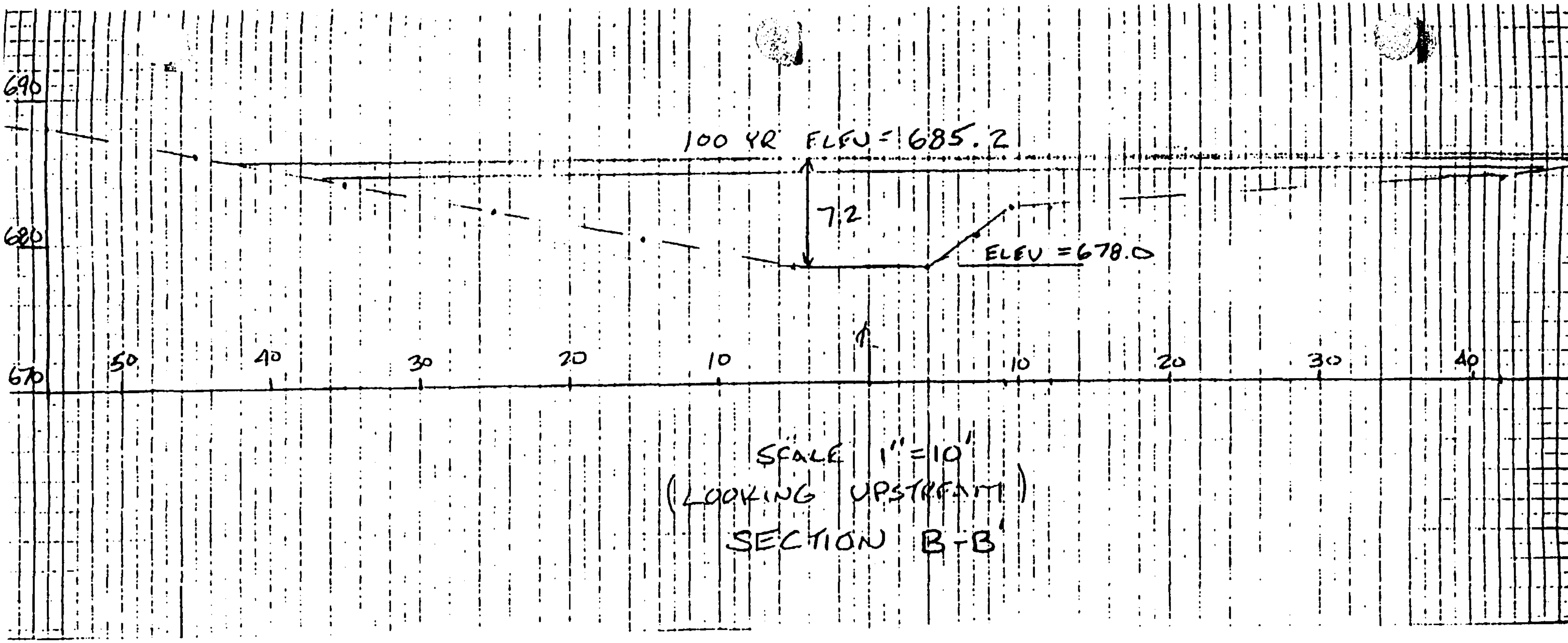
$AR^{2/3} = 618.3$

DEPTH	A	WP	R	$R^{2/3}$	$AR^{2/3}$
6.5	226	83	2.72	1.95	440.7
7	269	90	2.99	2.07	558.2
7.5	313	96	3.26	2.20	688.2

$$\frac{688.2 - 558.2}{618.3 - 558.2} = \frac{7.5 - 7}{x - 7}$$

$$x = 7.2$$

∴ 100 YEAR FLOW STAYS BEHIND FENCE


100 YR ELEV = 685.2
7.2
ELEV = 678.0
690
680
670
50
40
30
20
10
10
20
30
40
SCALE 1" = 10'
(LOOKING UPSTREAM)
SECTION B-B'

RUST **Rust Environment & Infrastructure**

CALCULATION SHEET

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Approved By ______ Date ______

CROSS - SECTION C
(SEE SHEET 9)

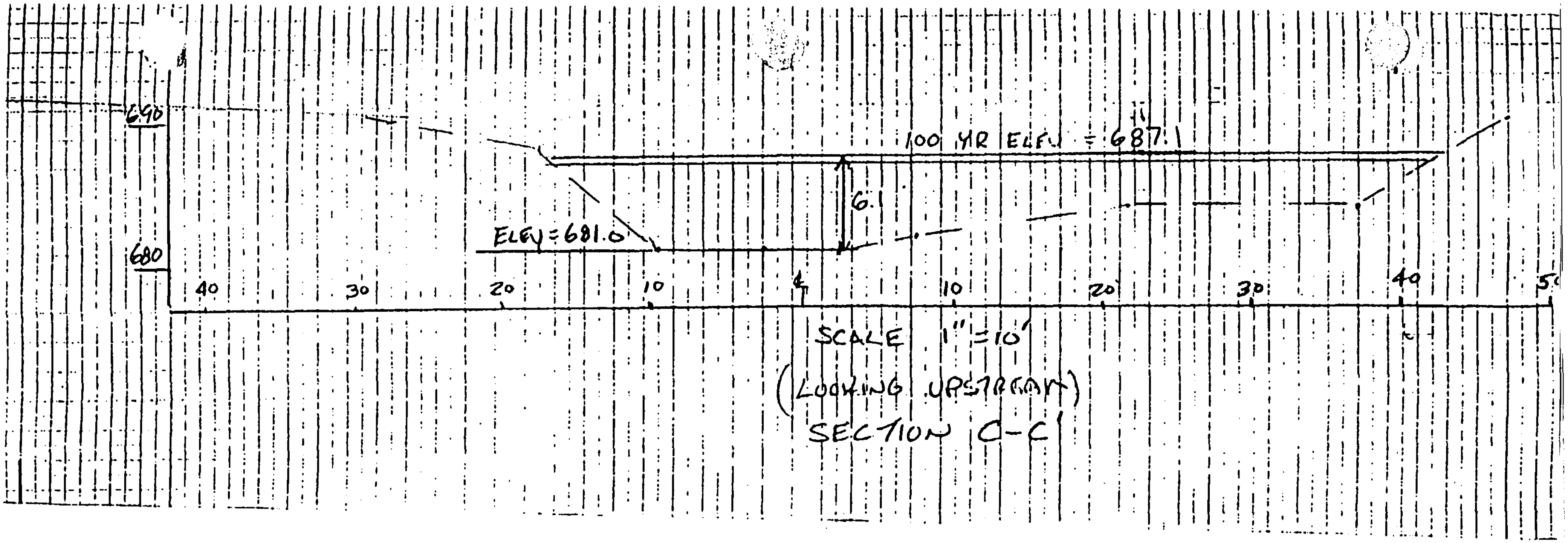
$AR^{2/3} = 618.3$

DEPTH	A	WP	R	$R^{2/3}$	$AR^{2/3}$
6	239	62	3.85	2.46	587.6
6.5	269	64	4.20	2.60	700.6

$$\frac{700.6 - 587.6}{618.3 - 587.6} = \frac{6.5 - 6}{X - 6}$$

$X = 6.1'$

∴ 100 YR FLOW STAYS IN BANKS


690
680
100 YR ELEV = 687.1
6.1
ELEV = 681.0
40
30
20
10
℄
10
20
30
40
50
SCALE 1" = 10'
(LOOKING UPSTREAM)
SECTION C-C'

RUST **Rust Environment & Infrastructure**

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CROSS SECTION D
(SEE SHEET 11)

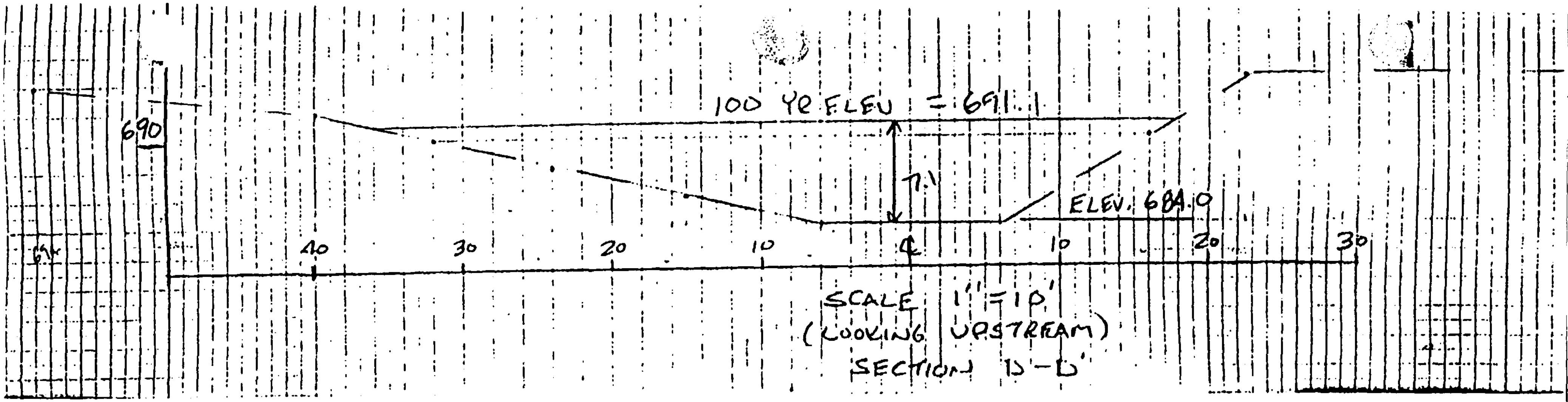
$AR^{2/3} = 618.3$

DEPTH	A	WP	R	$R^{2/3}$	$AR^{2/3}$
6	180	50.5	3.56	2.33	420.0
7	231	56	4.13	2.57	594.1
7.5	258	59	4.37	2.67	689.9

$$\frac{689.9 - 594.1}{618.3 - 594.1} = \frac{7.5 - 7}{x - 7}$$

$$x = 7.1'$$

$\therefore$ 100 YEAR FLOWS STAYS BEHIND FENCE


100 YR ELEV = 691.1
690
7.1
ELEV. 684.0
40
30
20
10
℄
10
20
30
SCALE 1" = 10'
(LOOKING UPSTREAM)
SECTION D-D'

RUST Rust Environment & Infrastructure

CALCULATION SHEET

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PROJECT ___

Prepared By CCV Date 2/14/96

Reviewed By ___ Date ___

Approved By ___ Date ___

CROSS SECTION E
(SEE SHEET 13)

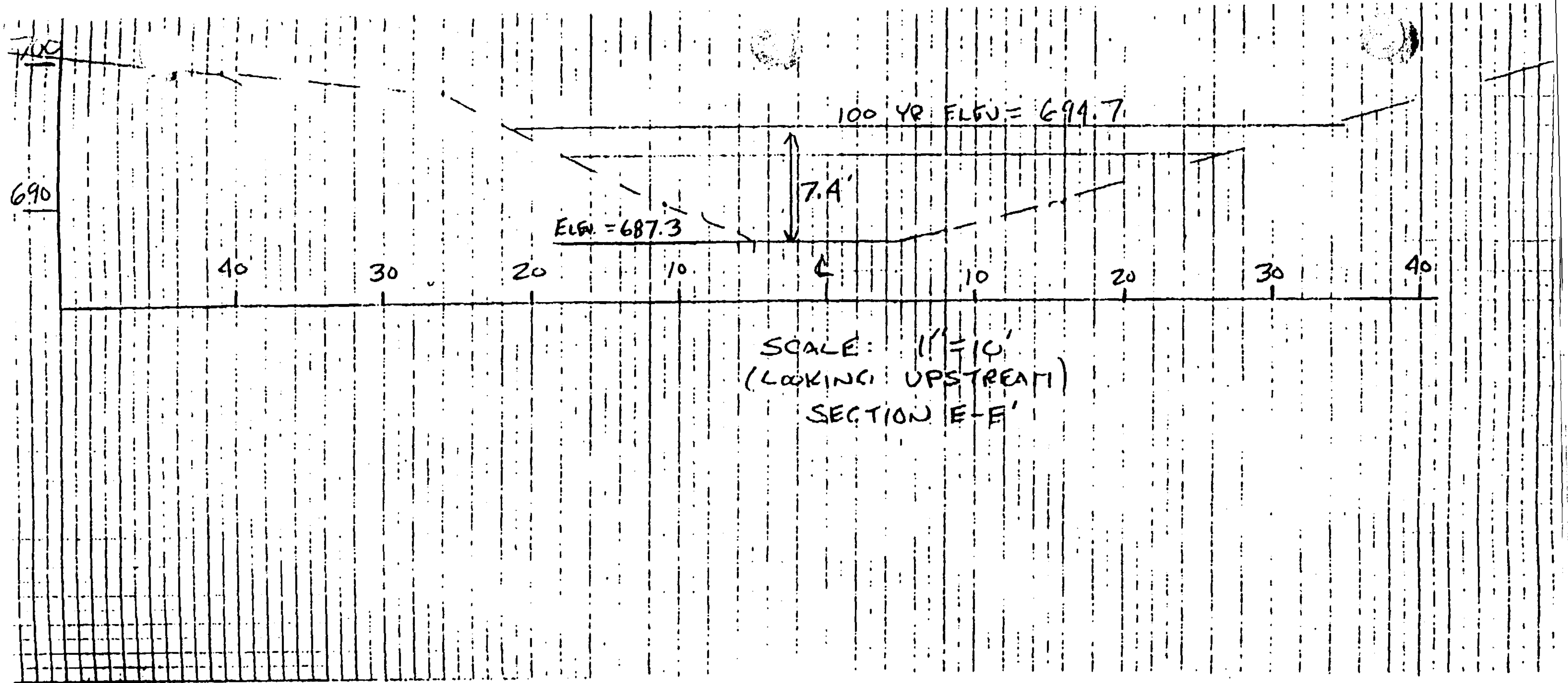
$AR^{2/3} = 618.3$

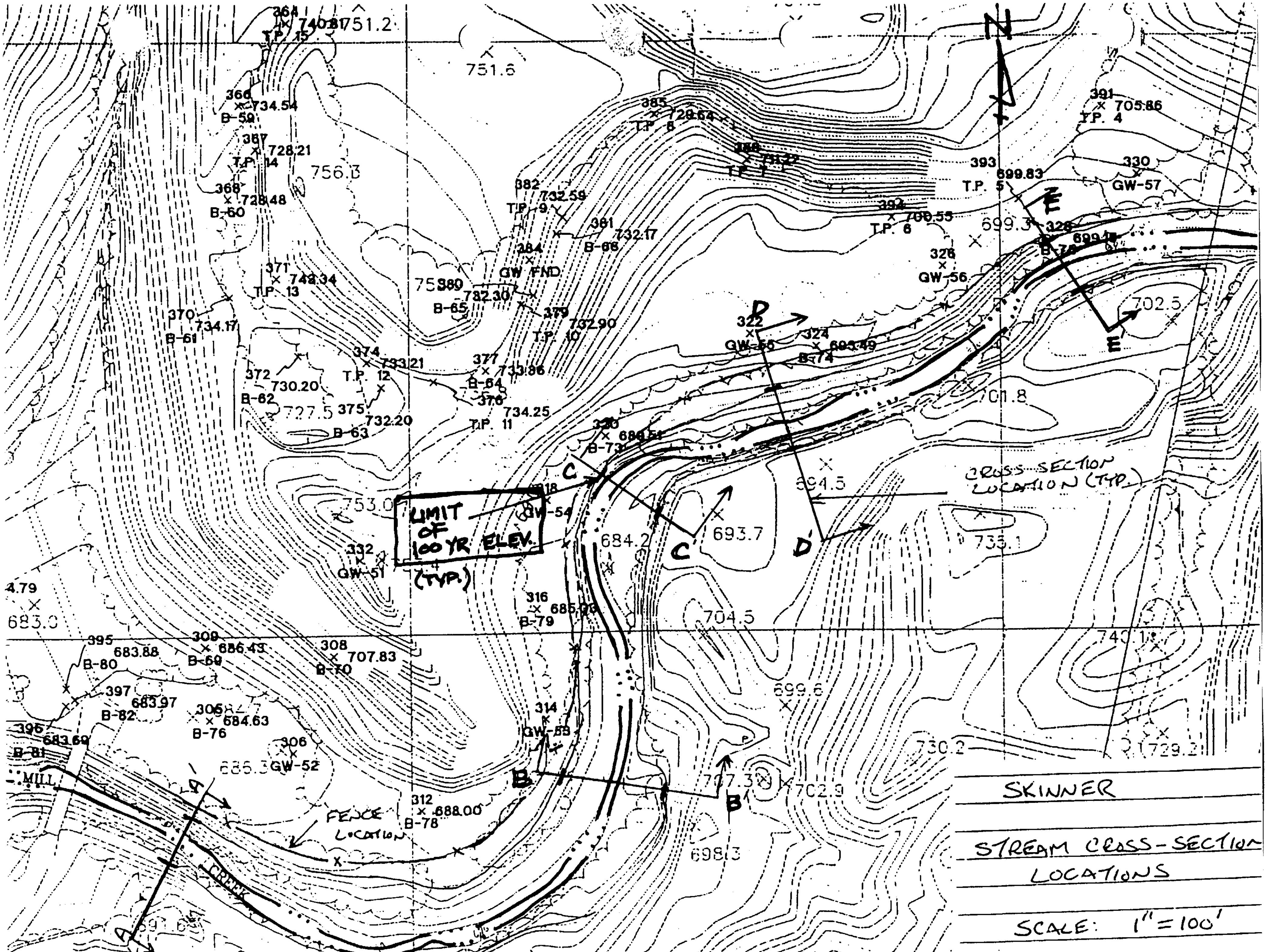
DEPTH	A	WP	R	$R^{2/3}$	$AR^{2/3}$
6	165	47	3.51	2.31	381.1
7	212	53	4.00	2.52	534.2
8	269	59	4.56	2.75	739.6

$$\frac{739.6 - 534.2}{618.3 - 534.2} = \frac{8-7}{x-7}$$

$$x = 7.4$$

∴ 100 YR FLOW STAYS IN BANKS


700
690
100 YR ELEV = 694.7
7.4'
ELEV = 687.3
40
30
20
10
℄
10
20
30
40
SCALE: 1" = 10'
(LOOKING UPSTREAM)
SECTION E-E'



SKINNER
STREAM CROSS-SECTION LOCATIONS
SCALE: 1" = 100'
LIMIT OF 100 YR ELEV. (TYP.)
CROSS SECTION LOCATION (TYP.)
FENCE LOCATION
CREEK
MILL
N

DRAINAGE & SEWERAGE-HYDRAULIC COMPUTATIONS-1

TABLE A-VALUES OF n, TO BE USED WITH KUTTER OR MANNING FORMULAS.†

SURFACE	CONDITION			
	BEST	GOOD	FAIR	BAD
Uncoated cast-iron pipe	0.012	0.013	0.014	0.015
Coated cast-iron pipe	0.011	0.012*	0.013*	
Commercial wrought-iron pipe, black	0.012	0.013	0.014	0.015
Commercial wrought-iron pipe, galvanized	0.013	0.014	0.015	0.017
Smooth brass and glass pipe	0.009	0.010	0.011	0.013
Smooth lockbar and welded OD pipe	0.010	0.011*	0.013*	
Riveted and spiral steel pipe	0.013	0.015*	0.017*	
Vitrified sewer pipe	{0.010 / 0.011}	0.013*	0.015	0.017
Common clay drainage tile	0.011	0.012*	0.014*	0.017
Glazed brickwork	0.011	0.012	0.013*	0.015
Brick in cement mortar, brick sewers	0.012	0.013	0.015*	0.017
Neat cement surfaces	0.010	0.011	0.012	0.013
Cement-mortar surfaces	0.011	0.012	0.013*	0.015
Concrete pipe	0.012	0.013	0.015*	0.016
Wood-stave pipe	0.010	0.011	0.012	0.013
Plank flumes:				
Planed	0.010	0.012*	0.013	0.014
Unplaned	0.011	0.013*	0.014	0.015
With battens	0.012	0.015*	0.016	
Concrete-lined channels	0.012	0.014*	0.016*	0.018
Cement-rubble surface	0.017	0.020	0.025	0.030
Dry rubble surface	0.025	0.030	0.033	0.035
Dressed ashlar surface	0.013	0.014	0.015	0.017
Semicircular metal flumes, smooth	0.011	0.012	0.013	0.015
Semicircular metal flumes, corrugated	0.0225	0.025	0.0275	0.030
Canals and ditches:				
Earth, straight and uniform	0.017	0.020	0.0225*	0.025
Rock cuts, smooth and uniform	0.025	0.030	0.033*	0.035
Rock cuts, jagged and irregular	0.035	0.040	0.045	
Winding sluggish canals	0.0225	0.025*	0.0275	0.030
Dredged earth channels	0.025	0.0275*	0.030	0.033
Canals with rough stony beds, weeds on earth banks	0.025	0.030	0.035*	0.040
Earth bottom, rubble sides	0.028	0.030[1]	0.033*	0.035
Natural stream channels:				
1. Clean, straight bank, full stage, no rifts or deep pools	0.025	0.0275	0.030	0.033
2. Same as (1), but some weeds and stones	0.030	0.033	0.035	0.040
3. Winding, some pools and shoals, clean	0.033	0.035	0.040	0.045
4. Same as (3), lower stages, more ineffective slope and sections	0.040	0.045	0.050	0.055
5. Same as (3), some weeds and stones	0.035	0.040	0.045	0.050
6. Same as (4), stony sections	0.045	0.050	0.055	0.060
7. Sluggish river reaches, rather weedy or with very deep pools	0.050	0.060	0.070	0.080
8. Very weedy reaches	0.075	0.100	0.125	0.150

Note: Asbestos-Cement Pipe (Transite) use 0.010.

* *Values commonly used in designing.*

WETLAND DELINEATION REPORT

FOR

SKINNER LANDFILL

Prepared for:

Skinner PRP Group

Project No. 72680.800

November 1995

Prepared by:
Rust Environment & Infrastructure Inc.
11785 Highway Drive
Cincinnati, Ohio 45241

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

1.0 INTRODUCTION AND PURPOSE

This report describes potential jurisdictional wetlands located at the Skinner Landfill. The wetland studies were conducted in conjunction with remediation activities at the site in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) since Skinner Landfill is listed on the National Priority List (NPL).

A field identification and delineation was conducted at Skinner Landfill to determine if any wetlands would be impacted by remediation efforts planned at the site. Field work was conducted October 2 and 5, 1995 by Rust Environment & Infrastructure Inc. (Rust) on behalf of the Skinner PRP Group. Where potential wetlands were identified, the wetland-upland boundaries were delineated and mapped based on the three mandatory criteria outlined in the 1987 U.S. Army Corps of Engineers (USACE) Wetlands Delineation Manual. The acreage of the identified wetlands were calculated from surveyed locations of the wetland boundary points.

Presented in this report is information on the site, background sources reviewed, field investigation procedures, and the results of the wetland delineations.

2.0 SITE BACKGROUND INFORMATION

2.1 SITE LOCATION AND DESCRIPTION

Skinner Landfill is located in West Chester, Butler County, Ohio, approximately 15 miles north of Cincinnati. The site is located in Township 3, Section 22, Range 2 and occupies approximately 80 acres, of which approximately 35 acres were used for waste disposal (Figure 1).

The site is bordered to the north by woodlands, a U.S. Postal Service branch office, and some residential housing. The East Fork of the Mill Creek crosses the southern end of the property, flowing primarily from east to west, and a small tributary, locally known as "Skinner Creek" crosses the eastern half of the property flowing from north to south. Cincinnati-Dayton Road, residential homes and commercial properties border the site to the west. To the east are railroad tracks, a utility line right-of-way, residential areas and woodlands. To the south are residential homes and undeveloped land.

The site is located in a highly dissected area that slopes from a till-mantled bedrock upland to a broad, flat-bottomed valley that is occupied by the main branch of Mill Creek. Elevations on the site range from a high of nearly 800 feet above mean sea level (msl) in the northeast to a low of 645 feet msl near the confluence of Skinner Creek and the East Fork of Mill Creek.

2.2 SITE HISTORY

The property was originally developed as a sand and gravel mining operation, and was subsequently used as a landfill from 1934 to 1990. According to EPA studies, materials deposited at the site include demolition debris, household refuse and a wide variety of chemical wastes. The waste disposal areas include a now-buried waste lagoon near the center of the site and a landfill. According to EPA studies, the buried lagoon was used for the disposal of paint wastes, ink wastes, creosote, pesticides, and other chemical wastes. The landfill area, located north and northeast of the buried lagoon, received predominantly demolition and landscaping debris.

In 1976, the Ohio EPA initiated an investigation of the site in response to reports of a black oily liquid that was observed during a fire call to the site. Before the Ohio EPA could complete the investigation, the landfill owners, the Skinners, covered the lagoon with a layer of demolition debris. Mr. Skinner further dissuaded the Ohio EPA from accessing the site by claiming that nerve gas, mustard gas and explosives were buried in the landfill. The Ohio EPA requested the assistance of the U.S. Army after obtaining this information. Mr. Skinner later retracted his statements concerning buried ordnance, and a 1992 Army records review revealed no evidence of munitions disposal at the site.

In 1982, the site was placed on the National Priority List by the USEPA based on information obtained during a limited investigation of the site that indicated groundwater contamination had occurred as a result of the buried wastes. In 1986 a Phase I Remedial Investigation was conducted that included sampling of groundwater, surface water, and soil as well as a biological survey of the East Fork of Mill Creek and Skinner Creek. A Phase II Remedial Investigation was conducted from 1989 to 1991 and involved further investigation of groundwater, surface water, soils and sediments. A Feasibility Study was completed in 1992.

2.3 BACKGROUND SOURCES

Various sources were obtained and examined prior to and concurrent with the wetlands field evaluation. The sources that were utilized in this effort are listed below:

- USGS 7.5-Minute Glendale, Ohio Topographic Quadrangle Map
- U.S. Department of the Interior National Wetland Inventory Map: Glendale, Ohio Quadrangle (Draft)
- Site Engineering Plans
- Aerial photograph dated April, 1993
- Butler County Soil Survey
- Hydric Soils List for Butler County, Ohio
- National List of Plant Species that Occur in Wetlands: Ohio
- 1987 USACE Wetlands Delineation Manual

2.4 THREATENED AND ENDANGERED SPECIES

The occurrence of endangered or threatened species was evaluated as part of this project. Both the Ohio Department of Natural Areas and Preserves and the U.S. Fish & Wildlife Service (USFWS) were contacted regarding endangered or threatened species located at or within a one-mile radius of the site. No occurrences of any threatened or endangered species have been recorded for the area of concern.

The USFWS did advise that the project area is within the range of two federally endangered species: Indiana Bat and Running Buffalo Clover. Observations were made at the site during the October field reconnaissances for suitable habitat for these species, such as large trees with exfoliating bark (for Indiana Bat) and semi-shaded, slightly disturbed areas (for Running Buffalo Clover). No such trees were observed at the site that would be suitable roosting habitats for

Indiana bat; however, potential habitat was observed in various areas for Running Buffalo Clover.

Correspondence regarding threatened and endangered species is included in Appendix I.

3.0 METHODS

Biologists from Rust conducted a field study of the site on October 2 and 5, 1995. The purpose of the study was to conduct a wetlands delineation of the property in order to identify potential wetland areas that might be adversely impacted by landfill remediation activities. Potential wetland areas were initially identified using aerial photographs and topographic maps of the site. The site was then field checked during the October site reconnaissance.

The wetlands delineation was conducted following the methods described in the 1987 Corps of Engineers Wetlands Delineation Manual. As such, strategic points along the wetland-upland boundaries were marked with engineering field flagging at approximate 35-foot intervals. The boundary points were determined using the routine level analysis and included an evaluation of the wetland vegetation, soils, and hydrologic indicators along the wetland-upland interface. All field notes and site observations were recorded on copies of Data Form 1 from the Wetlands Delineation Manual. These field Data Forms are included as Appendix II. The flags were then locked into the site topographic grid by J.T. King & Co., Inc., professional surveyors, who also determined the acreage of each area as indicated on Figure 2.

The vegetation was assessed for dominant species in the tree, shrub, and herbaceous layers of each community type. The percentage of aerial cover was visually estimated for the dominant species in each wetland area. The indicator status of dominant species in each community type was recorded. When more than 50 percent of the dominant species within a community were categorized as being obligate, facultative wetland and/or facultative species, the hydrophytic vegetation criterion was met.

The presence or absence of hydric soil was assessed at the site by means of digging a soil pit to depths of approximately 16 inches. The soil was then examined for hydric indicators. The soil sample locations were selected by examining the extent of wetland vegetation, the presence/absence of hydrologic indicators, and by topographical characteristics. Soil descriptions, including Munsell soil color, texture, moisture content, special features and horizon designation were recorded.

Hydrology was evaluated by the observation of surficial hydrologic indicators (such as drainage patterns, water marks, stained leaves, etc.) or by water level measured in the soil pits.

4.0 RESULTS

Results for the wetland delineation are summarized below and in Table 1. Photographs of the areas are provided in Appendix III. Locations are presented on Figure 2.

4.1 AREA A

Area A is located directly north of the landfill (most of this area is located outside of the landfill property) and is locally known as the "Duck Pond." This area is in a small topographic depression and is approximately 0.31 acres. There was no standing water at the time of the site visit; however, standing water was visible in the aerial photographs that were reviewed. The area is shown on the draft National Wetland Inventory (NWI) Map as a palustrine, unconsolidated bottom, intermittently exposed, excavated wetland. A copy of the NWI map is presented as Figure 3. Species observed in the wetland area included whitegrass, cocklebur, sycamore, American elm and black willow. The wetland indicator status of each of these species (as classified by the USFWS) is provided in Table 2. All of these species are adapted for wet conditions.

Soils in this area are classified by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) of Butler County, Ohio as either Wynn silt loam or "gravel pits". A copy of the soils map for the site is provided in Appendix IV. Wynn silt loam is listed as a non-hydric soil with hydric components in seeps. In the field, the soils were determined to be an olive gray (5 Y 4/2 as compared to Munsell soil color charts) silty loam with sharp contrasting yellowish red (5 YR 5/8) mottles. The standardized Munsell soil colors are identified by three components: hue, value and chroma. Soils with chromas of two or less are often diagnostic of hydric soils and soils that have a low chroma matrix and brightly colored mottles are often indicative of periodic water inundation.

Evidence of wetland hydrology was observed at this location with saturated soils, water marks on trees and sediment deposits being the primary hydrologic indicators.

4.2 AREA B

Area B is located along the eastern perimeter of the landfill, just outside of the limits of waste. This area is a low spot along a perimeter fence road and is approximately 0.063 acres in size. This area was not indicated as a wetland on the NWI draft map; however, it would be classified as a palustrine, forested, broad-leaved deciduous, temporarily flooded wetland according to the USFWS. Dominant plant species observed in this area consisted of Japanese honeysuckle, pawpaw, swamp white oak, sycamore, spotted touch-me-not, clearweed, sugar maple and white snakeroot. Of these dominant species, 50 percent are considered to be hydrophytic plants.

Soils in this area are also classified by the NRCS as Wynn silt loam and gravel pits. Results of a soil test pit dug at this location to a depth of approximately 16 inches showed that the soil consisted of a very dark grayish brown (10 YR 3/2) silty, sandy loam from 0 to 6 inches and a light olive brown (2.5 Y 5/4) clayey sand from 6 to 16 inches. No mottling was observed. Because of the sandy texture of this soil and the distinct color change at the 6 inch depth, this soil was considered to be hydric since the dark colored top layer is thought to be the result of a high organic matter content in the sandy soils.

Evidence of wetland hydrology was observed with surface water drainage patterns in the wetland the primary indicator.

4.3 AREA C

Area C (0.018 acres total) is composed of three small, separate areas all located south of the East Fork of Mill Creek (south of the landfill). These areas are not marked as wetlands on the draft NWI map, but would be characterized as palustrine, forested, broad-leaved deciduous, seasonally flooded wetlands. Each of the small areas are bowl-shaped depressions, with a large amount of leaf litter accumulated in the bottom of the topographic low. At the time of the site reconnaissance, two of the areas contained standing water. Dominant species in these locations included sycamore, clearweed, and red elm; all hydrophytic species.

The soils in this area are also classified by the NRCS as Wynn silt loam. A soil test pit was dug to approximately 12 inches at two of these locations. Soils encountered consisted of primarily decomposed leaves (like a peat) to a depth of approximately 12 inches.

The primary indicators of wetland hydrology observed for these areas were standing water, water stained leaves, water marks on trees and drainage patterns.

4.4 AREA D

Area D is located southwest of landfill boundary, just north of the East Fork of the Mill Creek. Area D is approximately 0.03 acres in size and, although not indicated on the draft NWI map, would be classified by the USFWS as a palustrine, emergent, temporarily flooded wetland. Dominant species consisted of New England aster, small white aster, tall goldenrod, eastern cottonwood saplings, tick-trefoil, and teasel. The majority of these species are facultative species.

Soils in this area have been significantly altered by landfill and other earth-moving activities in this area; therefore a natural soil profile does not exist in this area. Although this area has been disturbed, it is believed that the soils in this area are functioning as hydric soils and will develop the hydric characteristics over time. This conclusion is based on the existing vegetation and surface water run-off patterns in this area.

Standing water was observed during the site reconnaissance with other primary indicators of wetland hydrology being sediment deposits on the herbaceous vegetation and local drainage patterns.

4.5 AREA E

Area E is located west of the landfill boundary and east of the "Diving Pond" in an area used to store various scrap items including metal, hoses, appliances, car and truck parts, aluminum siding, and wire. This area is not indicated on the draft NWI map; however, it would probably be considered a palustrine, scrub-shrub, broad-leaved deciduous, temporarily flooded wetland. The area is approximately 0.26 acres in size and is dominated by black willows in the overstory and New England aster, sedges, and rushes in the herbaceous layer (all hydrophytic species).

As in Area D, the soils in this area have been significantly disturbed by various earth-moving activities and therefore were not profiled in the field. Primary indicators of wetland hydrology included inundation, soil saturation, water marks on trees and drift lines.

4.6 ADDITIONAL AREAS EVALUATED

Other areas were evaluated at the site that did not meet all three criteria of a wetland. These areas included the intermittent streams and surrounding lands directly south of the landfill area and areas of topographic lows on the landfill proper and areas that may be impacted by proposed remediation (such as borrow areas). The limits of the wetlands investigation are shown on Figure 2.

5.0 FUNCTIONAL ANALYSIS

As part of the wetland delineation, a qualitative functional analysis was conducted for identified wetlands at the site. Because of the small size, isolation and temporary nature of each of the identified wetlands, the functions provided are severely limited. In general, each of the wetland areas provide limited wildlife habitat, floodflow alteration (i.e., retention of storm flows), nutrient removal and transformation. The larger wetland areas (Wetlands "A" and "E") would provide a more important role in these functions, although, as stated earlier, given the small size of each of these areas, the functions provided are limited.

6.0 SUMMARY

Based in observations made in October 1995, Rust identified five potential wetland areas at Skinner Landfill that may be impacted by planned remediation activities. These areas total approximately 0.68 acres, as shown on Figure 2 and are primarily palustrine emergent and forested wetlands. The wetlands identified are located primarily around the perimeter of the landfill. Each of these areas met all three criteria of a wetland, specifically, wetland vegetation, soils and hydrology.

7.0 REFERENCES

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Weishaupt, Clara, 1985. A Descriptive Key to the Grasses of Ohio Based on Vegetative Characters. College of Biological Sciences, Ohio State University, Columbus, Ohio.

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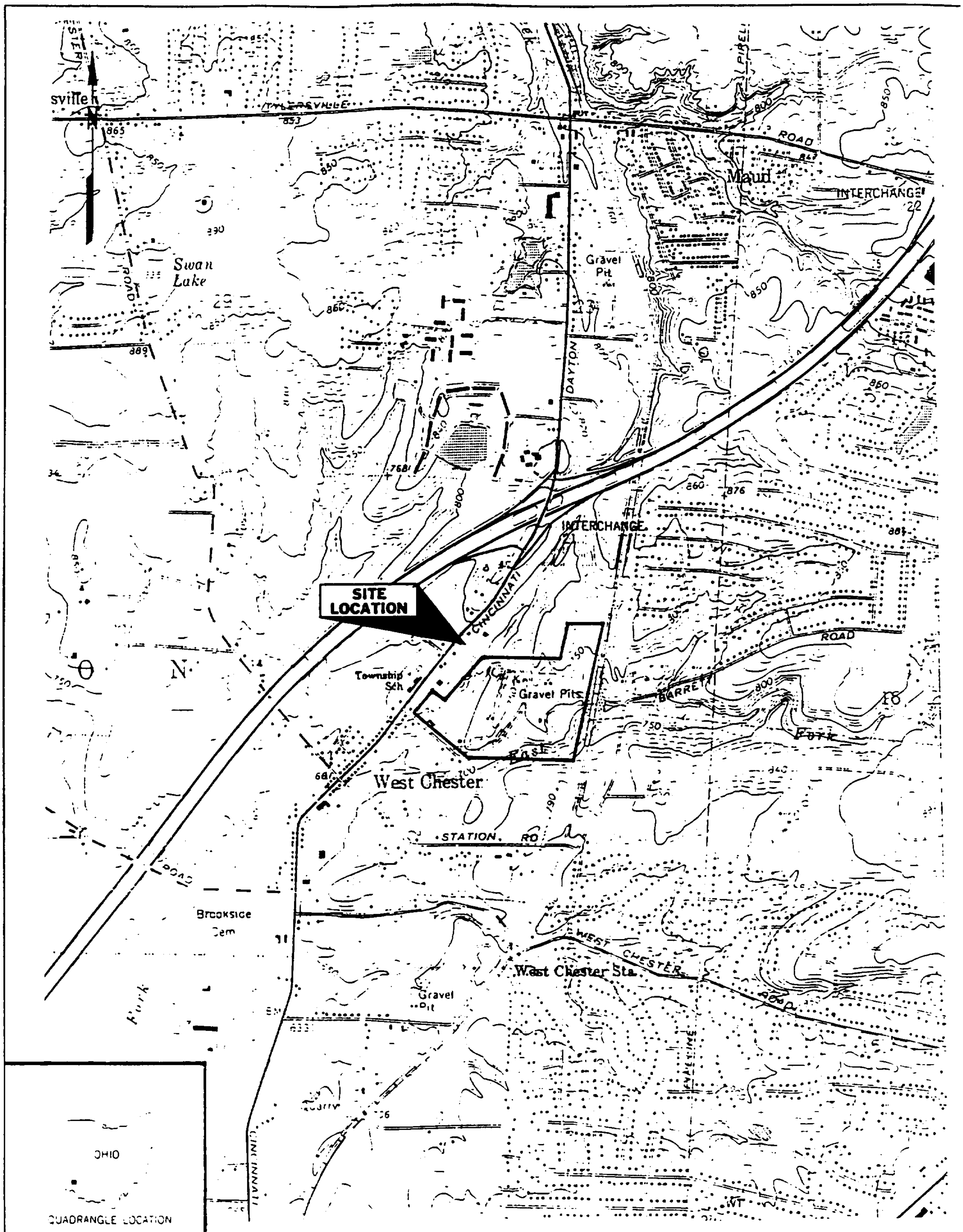
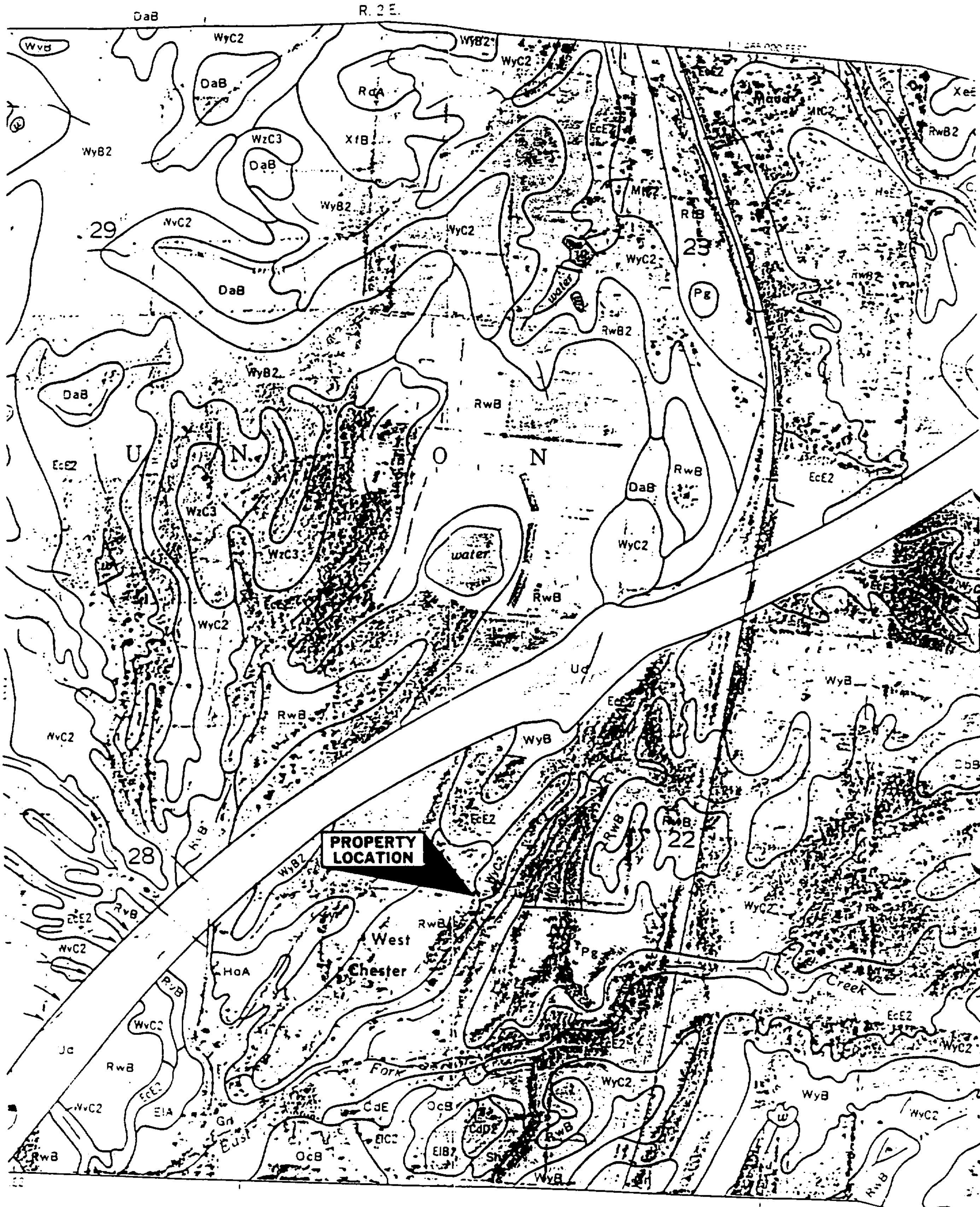


Skinner PRPs
Skinner Landfill
Wetland Delineation Study
SITE LOCATION MAP

Scale: 1" = 2000'

RUST
Rust Environment & Infrastructure

Project No. 72680.800 Figure 1



BUTLER COUNTY, OHIO — SHEET NUMBER 62

Skinner PRPs Skinner Landfill Wetland Delineation Study BUTLER COUNTY, OHIO, SOIL SURVEY MAP Scale: 1" = 0.25 mile	RUST Rust Environment & Infrastructure Project No. 72680.800 Figure Appendix

RUST Rust Environment & Infrastructure

CALCULATION SHEET

PAGE 3 OF ___
PROJECT NO. 72680

CLIENT SKINNER	SUBJECT ___	Prepared By CCV Date 3/13/96
PROJECT ___	___	Reviewed By ___ Date ___
___	___	Approved By ___ Date ___

CALCULATIONS

A = DRAINAGE AREA = 2.88 SQ MILES
(USE 3 SQ MILES)

P = AVERAGE ANNUAL PRECIPITATION = 41 INCHES
[REF # 1] SEE SHEET 5

BDF = BASIN DEVELOPMENT FACTOR = 7
SEE SHEET 6 FOR DETERMINATION

100 YR MULTIPLE REGRESSION EQUATION [REF #1]

$$UQ_{100} = 321\,(A)^{0.79}\,(P-30)^{0.76}\,(13-BDF)^{-0.33}$$

$$UQ_{100} = (764.6)\quad(6.2)\quad(0.55 \quad = \underline{2619}\ \text{CFS}$$

25 YR MULTIPLE REGRESSION EQUATION

$$UQ_{25} = 265(A)^{0.76}\,(P-30)^{0.72}\,(13-BDF)^{-0.37}$$

$$(610.7)\quad(5.6)\quad(0.52) \quad = \underline{1762}\ \text{CFS}$$

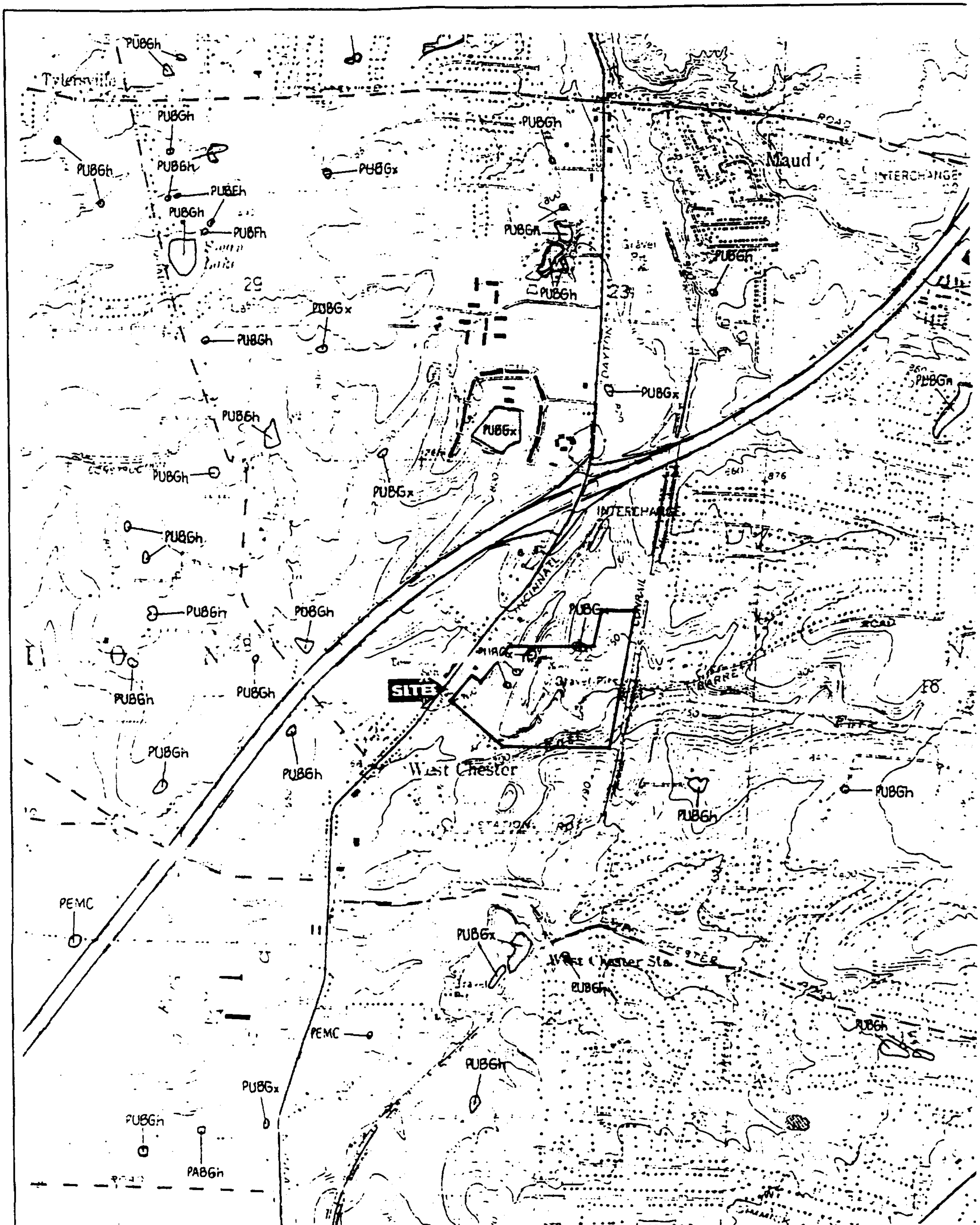
Rev. 11/94 scale: 4 sq./inch F051/General

SKINNER LANDFILL
REMEDIAL DESIGN
FINAL DESIGN (100%) PHASE I REPORT

VOLUME II OF IV, PART 2

THE FOLLOWING MAPS MAY BE VIEWED AT THE U.S. EPA RECORD CENTER, 77 WEST JACKSON BLVD., 7TH FLOOR, CHICAGO, ILLINOIS

1) MAP OF SKINNER LANDFILL: J.T. KING & CO., INC. 11/16/94



Skinner PRPs
Skinner Landfill
Wetland Delineation Study
USFWS NATIONAL WETLAND INVENTORY MAP

Scale: 1" = 2000'

RUST
Rust Environment & Infrastructure

Project No. 72680.800 Figure 3

TABLE 1

SUMMARY OF WETLAND AREAS AT SKINNER LANDFILL

AREA	ACREAGE	USFWS CLASSIFICATION
A	0.31	Palustrine, unconsolidated bottom, intermittently exposed, excavated wetland
B	0.063	Palustrine, forested, broad-leaved deciduous, temporarily flooded
C	0.018	Palustrine, forested, broad-leaved deciduous, seasonally flooded
D	0.03	Palustrine, emergent, temporarily flooded
E	0.26	Palustrine, scrub-shrub, broad-leaved deciduous, temporarily flooded

TABLE 2
VEGETATION SPECIES AND THEIR NATIONAL WETLAND INDICATOR STATUS

Common Name	Scientific Name	Status*
American Elm	Ulmus americana	FACW-
American Three-Square	Scirpus americanus	OBL
Black Willow	Salix nigra	FACW
Clearweed	Pilea pumila	FACW
Cocklebur	Xanthium strumarium	FAC
Cottonwood	Populus deltoides	FAC
Japanese Honeysuckle	Lonicera japonica	FAC-
New England Aster	Aster novae-angliae	FACW-
Pawpaw	Asimina triloba	FACU+
Red Elm	Ulmus rubra	FAC
Sedges	Carex sp.	FACW
Small White Aster	Aster vimineus	FAC
Spotted Touch-Me-Not	Impatiens capensis	FACW
Sugar Maple	Acer saccharum	FACU-
Swamp Chestnut Oak	Quercus michauxii	FACW
Sycamore	Platanus occidentalis	FACW-
Tall Goldenrod	Solidago altissima	FACU-
Teasel	Dipsacus sylvestris	NI
Tick-Trefoil	Desmodium sp.	FAC
Whitegrass	Leersia virginica	FACW
White Snakeroot	Ageratina altissima	FACU-

*Status:

UPL	=	Occur almost always (>99%) in nonwetlands
FACU	=	Usually occur (67% - 99%) in nonwetlands, but occasionally found in wetlands
FAC	=	Equally likely to occur in wetlands or nonwetlands (34% - 66%)
FACW	=	Usually occur (67% - 99%) in wetlands, but occasionally found in nonwetlands
OBL	=	Occur almost always (>99%) in wetlands
NI	=	No Indicator Status Assigned

OHIO Department of Natural Resources

RECEIVED AUG 3 1995

George V. Voinovich • Governor
Donald C. Anderson • Director

August 30, 1995

Karen A. Fields
Rust Environment & Infrastructure Inc.
11785 Highway Dr., Ste. 100
Cincinnati, OH 45241

Dear Ms. Fields:

After reviewing our Natural Heritage maps and files, I have found that the Division of Natural Areas and Preserves has no records of rare species in the vicinity of the Skinner Landfill, Glendale Quad., Union Township, Bulter County (Project #72680.200).

There are no existing or proposed state nature preserves or scenic rivers at the project site. We are also unaware of any unique ecological sites, geologic features, breeding or non-breeding animal concentrations, champion trees, or state parks, forests or wildlife areas in the project vicinity.

Our inventory program has not completely surveyed Ohio and relies on information supplied by many individuals and organizations. Therefore, a lack of records for any particular area is not a statement that rare species or unique features are absent from that site. Please note that we inventory only high-quality plant communities and do not maintain an inventory of all Ohio wetlands.

Please contact me at (614) 265-6409 if I can be of further assistance.

Sincerely,

Treva J. Knasel

Treva J. Knasel
Ecological Analyst
Division of Natural Areas & Preserves

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
6950-H Americana Parkway
Reynoldsburg, Ohio 43068

IN REPLY REFER TO:

RECEIVED OCT 18 1995

October 6, 1995

Ms. Karen Fields
RUST Environment and Infrastructure
11785 Highway Drive, Suite 100
Cincinnati, Ohio 45241

Dear Ms. Fields:

This responds to your request for information about endangered species that may occur in the vicinity of the Skinner Landfill, Butler County, Ohio. These comments have been prepared under the authority of the Endangered Species Act of 1973 as amended.

ENDANGERED SPECIES COMMENTS: The Skinner Landfill in Butler County, Ohio lies within the range of the Indiana bat and running buffalo clover, federally listed endangered species. Should your information indicate that these, or other, federally listed endangered or threatened species have been or will be affected by project activities, please reinitiate consultation with this office.

Two divisions of the Ohio Department of Natural Resources, the Division of Wildlife (DOW, 614-265-6300) and the Division of Natural Areas and Preserves (DNAP, 614-265-6472), maintain lists of plants and animals of concern to the State of Ohio. If you have not already done so, please contact each of these agencies to obtain site-specific information on species of state concern.

If you have questions or we may be of further assistance in this matter please contact Mr. Bill Kurey of this office at 614-469-6923.

Sincerely,

Ken Mullen

for Kent E. Kroonemeyer
Supervisor

Division of Wildlife

1840 Belcher Drive, Columbus, Ohio 43224-1329 • 614-265-6308 • Michael J. Budzik, *Chief*

November 29, 1995

Rust Environmental & Infrastructure Inc.
11785 Highway Drive, Suite 100
Cincinnati, OH 45241
Attn: Karen Fields

RE: Skinner Landfill, Project No. 72680.800

Dear Ms. Fields:

This letter is in response to your request for threatened and endangered species consultation on the above referenced project. The ODNR, Division of Natural Areas & Preserves maintains the Ohio Natural Heritage Program, which is the state's most comprehensive source of information on the location of listed flora, fauna, and unique natural areas. Your request has been forwarded to their office for response.

Should you become aware of the presence of a listed animal species in the project area, the Division of Wildlife is availabel to provide guidance on avoiding or minimizing impacts to the population and/or habitat. If you should need further assistance feel free to contact my staff member, Bob Fletcher, at the number listed above.

Sincerely,

John H. Marshall
Environmental Affairs Specialist

cc: Patricia Jones, DNAP

C:ECORES23

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Skinner Landfill	Date: 10/2/95
Applicant/Owner: Skinner PRP's	County: Butler
Investigator: K. Fields B. Pederson	State: OH
Do Normal Circumstances exist on the site? **Yes** No	Community ID:
Is the site significantly disturbed (Atypical Situation)? Yes **No**	Transect ID:
Is the area a potential Problem Area? Yes **No** (If needed, explain on reverse.)	Plot ID: "Duck Pond" (Area A)

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Leersia virginica	Herb	FACW	9.		
2. Xanthium strumarium	Herb	FAC	10.		
3. Platanus occidentalis	Tree	FACW-	11.		
4. Ulmus americana	Tree	FACW-	12.		
5. Salix nigra	Tree	FACW+	13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 100%

Remarks: All hydrophytic species dominant.

HYDROLOGY

___ Recorded Data (Describe in Remarks):
- ___ Stream, Lake, or Tide Gauge
- ___ Aerial Photographs
- ___ Other

✓ No Recorded Data Available

Field Observations:

Depth of Surface Water: ________ (in.)

Depth to Free Water in Pit: ________ (in.)

Depth to Saturated Soil: ~3" (in.)

Wetland Hydrology Indicators:

Primary Indicators:
- ___ Inundated
- ✓ Saturated in Upper 12 Inches
- ✓ Water Marks - on trees
- ___ Drift Lines
- ✓ Sediment Deposits
- ___ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):
- ___ Oxidized Root Channels in Upper 12 Inches
- ___ Water-Stained Leaves
- ___ Local Soil Survey Data
- ___ FAC-Neutral Test
- ___ Other (Explain in Remarks)

Remarks: Water marks on trees for high water mark. Soils saturated near surface.

SOILS

Map Unit Name (Series and Phase): Wynn silt loam?/Gravel pits

Drainage Class: ____

Field Observations Confirm Mapped Type? Yes No

Taxonomy (Subgroup): ____

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-14"	A/B	5Y 4/2	5YR 5/8	5-10%/Sharp	Silty loam

Hydric Soil Indicators:

- __ Histosol
- __ Histic Epipedon
- __ Sulfidic Odor
- ✓ Aquic Moisture Regime
- ✓ Reducing Conditions
- __ Gleyed or Low-Chroma Colors
- __ Concretions
- __ High Organic Content in Surface Layer in Sandy Soils
- __ Organic Streaking in Sandy Soils
- ✓ Listed on Local Hydric Soils List
- __ Listed on National Hydric Soils List
- __ Other (Explain in Remarks)

Remarks: Wynn silt loam is listed as a non-hydric soils w/ hydric components in seeps by SCS. This area is slightly bowl-shaped.

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes No (Circle)
Wetland Hydrology Present? Yes No
Hydric Soils Present? Yes No

(Circle)
Is this Sampling Point Within a Wetland? Yes No

Remarks: Hydrophytic vegetation dominant; water marks on trees indicating periodic inundation; + low matrix chroma soils with bright mottles.

Approved by HQUSACE 3/92

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Skinner Landfill Applicant/Owner: Skinner PRP's Investigator: K. Fields, B. Pederson	Date: 10/2/95 County: Butler State: OH
Do Normal Circumstances exist on the site? Yes No Is the site significantly disturbed (Atypical Situation)? Yes No Is the area a potential Problem Area? Yes No (If needed, explain on reverse.)	Community ID: Transect ID: Plot ID: "Area B"

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Lonicera japonica	Shrub	FAC-	9.		
2. Asimina triloba	Shrub	FACU+	10.		
3. Quercus michauxii	Understory	FACW	11.		
4. Platanus occidentalis	Tree	FACW-	12.		
5. Impatiens capensis	Herb	FACW	13.		
6. Pilea pumila	Herb	FACW	14.		
7. Acer saccharum	Tree	FACU-	15.		
8. Ageratina altissima	Herb	FACU-	16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 50%

Remarks: Species 50% hydrophytic

HYDROLOGY

___ Recorded Data (Describe in Remarks):
  ___ Stream, Lake, or Tide Gauge
  ___ Aerial Photographs
  ___ Other
✓ No Recorded Data Available

Field Observations:

Depth of Surface Water: ________ (in.)

Depth to Free Water in Pit: ________ (in.)

Depth to Saturated Soil: ________ (in.)

Wetland Hydrology Indicators:
Primary Indicators:
  ___ Inundated
  ___ Saturated in Upper 12 Inches
  ___ Water Marks
  ___ Drift Lines
  ___ Sediment Deposits
  ✓ Drainage Patterns in Wetlands
Secondary Indicators (2 or more required):
  ___ Oxidized Root Channels in Upper 12 Inches
  ___ Water-Stained Leaves
  ___ Local Soil Survey Data
  ___ FAC-Neutral Test
  ___ Other (Explain in Remarks)

Remarks: In a small depression - receives run-off from all directions with no apparent outlet.

SOILS

Map Unit Name
(Series and Phase): Wynn silt loam / Gravel pits

Drainage Class: ____
Field Observations
Confirm Mapped Type? Yes No

Taxonomy (Subgroup): ____

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-6	A/B	10YR 3/2	None	NA	Silty, sandy loam
6-16	B	2.5Y 5/4	None	NA	Clayey sand

Hydric Soil Indicators:

- ___ Histosol
- ___ Histic Epipedon
- ___ Sulfidic Odor
- ___ Aquic Moisture Regime
- ___ Reducing Conditions
- ___ Gleyed or Low-Chroma Colors
- ___ Concretions
- ✓ High Organic Content in Surface Layer in Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks: District color change from top 6" to next (6-16"). 6-16" portion very sandy in texture. Assume color on top (dark brown) is result of high organic content for sandy soils.

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes No (Circle)
Wetland Hydrology Present? Yes No
Hydric Soils Present? Yes No

(Circle)
Is this Sampling Point Within a Wetland? Yes No

Remarks: Hydrophytic vegetation is co-dominant. Area is in a topographic low; sandy soils with dark layer over a lighter color, sandy soil are hydric → therefore, area is a wetland.

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Skinner Landfill Applicant/Owner: Skinner PRPs Investigator: K. Fields, B. Pederson	Date: 10/5/95 County: Butler State: OH
Do Normal Circumstances exist on the site? Yes No Is the site significantly disturbed (Atypical Situation)? Yes No Is the area a potential Problem Area? Yes No (If needed, explain on reverse.)	Community ID: Transect ID: Plot ID: Area C

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Platanus occidentalis	Tree	FACW-	9.		
2. Ulmus rubra	Tree	FAC	10.		
3. Pilea pumila	Herb	FACW	11.		
4.			12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 100%

Remarks:
All hydrophytic species

HYDROLOGY

___ Recorded Data (Describe in Remarks): ___ Stream, Lake, or Tide Gauge ___ Aerial Photographs ___ Other ✓ No Recorded Data Available	Wetland Hydrology Indicators: Primary Indicators: ___ Inundated ___ Saturated in Upper 12 Inches ✓ Water Marks ___ Drift Lines ___ Sediment Deposits ✓ Drainage Patterns in Wetlands Secondary Indicators (2 or more required): ___ Oxidized Root Channels in Upper 12 Inches ✓ Water-Stained Leaves ___ Local Soil Survey Data ___ FAC-Neutral Test ___ Other (Explain in Remarks)
Field Observations: Depth of Surface Water: ______ (in.) Depth to Free Water in Pit: ______ (in.) Depth to Saturated Soil: ______ (in.)	

Remarks: Area C is comprised of 3 separate small areas each located in a small, bowl-shaped depression - appear to have been created by creek flooding or a former oxbow.

SOILS

Map Unit Name (Series and Phase): Wynn silt loam

Drainage Class: ______

Field Observations Confirm Mapped Type? Yes No

Taxonomy (Subgroup): ______

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-12	A/B	5YR 2.5/1	NA	NA	Decomposed leaves

Hydric Soil Indicators:

- ___ Histosol
- ___ Histic Epipedon
- ___ Sulfidic Odor
- ___ Aquic Moisture Regime
- ___ Reducing Conditions
- ___ Gleyed or Low-Chroma Colors
- ___ Concretions
- ___ High Organic Content in Surface Layer in Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks: Soil consisted primarily of decomposed leaves - like a peat This "peat" layer was approximately 8-12" thick.

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	Yes	No	(Circle)
Wetland Hydrology Present?	Yes	No	
Hydric Soils Present?	Yes	No	

Is this Sampling Point Within a Wetland? Yes No (Circle)

Remarks: Meets all 3 criteria; area C is a wetland.

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Skinner Landfill	Date: 10/5/95
Applicant/Owner: Skinner PRPs	County: Butler
Investigator: K. Fields B. Pederson	State: OH
Do Normal Circumstances exist on the site? Yes No (Yes circled)	Community ID:
Is the site significantly disturbed (Atypical Situation)? Yes No (Yes circled)	Transect ID:
Is the area a potential Problem Area? Yes No (No circled) (If needed, explain on reverse.)	Plot ID: "Area D"

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Aster novae-angliae	Herb	FACW-	9.		
2. Aster vimineus	Herb	FAC	10.		
3. Solidago altissima	Herb	FACU-	11.		
4. Populus deltoides	Herb	FAC	12.		
5. Desmodium sp	Herb	FAC	13.		
6. Dipsacus sylvestris	Herb	NI	14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 80%

Remarks: Mostly facultative plant species, but area appears to have been man-made + therefore recently created.

HYDROLOGY

___ Recorded Data (Describe in Remarks): ___ Stream, Lake, or Tide Gauge ___ Aerial Photographs ___ Other ✓ No Recorded Data Available	Wetland Hydrology Indicators: Primary Indicators: ✓ Inundated ✓ Saturated in Upper 12 Inches ___ Water Marks ___ Drift Lines ___ Sediment Deposits ___ Drainage Patterns in Wetlands
Field Observations: Depth of Surface Water: ______ (in.) Depth to Free Water in Pit: ______ (in.) Depth to Saturated Soil: ______ (in.)	Secondary Indicators (2 or more required): ___ Oxidized Root Channels in Upper 12 Inches ___ Water-Stained Leaves ___ Local Soil Survey Data ___ FAC-Neutral Test ___ Other (Explain in Remarks)

Remarks: Inundated at surface - saturated elsewhere. Receives surface water run-off from adjacent hillside + water ponds in this area before either seeping into ground or running over gravel road to a drainage.

SOILS

Map Unit Name (Series and Phase): Gravel Pits

Drainage Class: ______

Field Observations Confirm Mapped Type? Yes No

Taxonomy (Subgroup): ______

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
NA	A/B	NA	NA	NA	Fill material

Hydric Soil Indicators:

- ___ Histosol
- ___ Histic Epipedon
- ___ Sulfidic Odor
- ___ Aquic Moisture Regime
- ___ Reducing Conditions
- ___ Gleyed or Low-Chroma Colors
- ___ Concretions
- ___ High Organic Content in Surface Layer in Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks: Soils have been drastically altered by landfill activities - no real soil profile left. Surface consisted of fill - gravel, concrete, etc.

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes No (Circle)
Wetland Hydrology Present? Yes No
Hydric Soils Present? Yes No
→ will become

(Circle)
Is this Sampling Point Within a Wetland? Yes No

Remarks: Although soils are disturbed, believe over time this area will have hydric soils if left alone based on vegetation and surface water patterns in this area.

DATA FORM
ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: Skinner Landfill	Date: 10/5/95
Applicant/Owner: Skinner PRP's	County: Butler
Investigator: K Fields B. Pederson	State: OH
Do Normal Circumstances exist on the site? **Yes** No	Community ID:
Is the site significantly disturbed (Atypical Situation)? **Yes** No	Transect ID:
Is the area a potential Problem Area? Yes **No** (If needed, explain on reverse.)	Plot ID: "Area E"

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1. Salix nigra	Tree	FACW+	9.		
2. Aster novae-angliae	Herb	FACW-	10.		
3. Carex sp.	Herb	FACW	11.		
4. Scirpus americanus	Herb	OBL	12.		
5.			13.		
6.			14.		
7.			15.		
8.			16.		

Percent of Dominant Species that are OBL, FACW or FAC (excluding FAC-). 100%

Remarks: All hydrophytic species

HYDROLOGY

___ Recorded Data (Describe in Remarks):
- ___ Stream, Lake, or Tide Gauge
- ___ Aerial Photographs
- ___ Other

✓ No Recorded Data Available

Field Observations:

Depth of Surface Water: ______ (in.)

Depth to Free Water in Pit: ______ (in.)

Depth to Saturated Soil: ______ (in.)

Wetland Hydrology Indicators:

Primary Indicators:
- ✓ Inundated
- ✓ Saturated in Upper 12 Inches
- ___ Water Marks
- ___ Drift Lines
- ___ Sediment Deposits
- ___ Drainage Patterns in Wetlands

Secondary Indicators (2 or more required):
- ___ Oxidized Root Channels in Upper 12 Inches
- ___ Water-Stained Leaves
- ___ Local Soil Survey Data
- ___ FAC-Neutral Test
- ___ Other (Explain in Remarks)

Remarks: Standing water in some areas - saturated most everywhere else.

SOILS

Map Unit Name (Series and Phase): Gravel Pits

Drainage Class: ______

Field Observations Confirm Mapped Type? Yes No

Taxonomy (Subgroup): ______

Profile Description:

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
NA	A/B	NA	NA	NA	Fill material

Hydric Soil Indicators:

- ___ Histosol
- ___ Histic Epipedon
- ___ Sulfidic Odor
- ___ Aquic Moisture Regime
- ___ Reducing Conditions
- ___ Gleyed or Low-Chroma Colors
- ___ Concretions
- ___ High Organic Content in Surface Layer in Sandy Soils
- ___ Organic Streaking in Sandy Soils
- ___ Listed on Local Hydric Soils List
- ___ Listed on National Hydric Soils List
- ___ Other (Explain in Remarks)

Remarks: Soils not applicable since on top of a former landfill - waste evident at surface (ie, concrete, tires, metal, etc.).

WETLAND DETERMINATION

Hydrophytic Vegetation Present? Yes No (Circle)
Wetland Hydrology Present? Yes No
Hydric Soils Present? Yes No
Inferred

(Circle)
Is this Sampling Point Within a Wetland? Yes No

Remarks: Area has been disturbed by landfill activities - soils have been drastically altered. Area is in a topographic low spot - no apparent outlet for surface water run-off.

Photo 1: The eastern half of the northwestern portion of the former landfill area, looking north.

SKINNER PRPS
SKINNER LANDFILL
WEST CHESTER, BUTLER COUNTY, OHIO
PROJECT NO. 72680.800

SITE PHOTOGRAPHS

RUST ENVIRONMENT & INFRASTRUCTURE

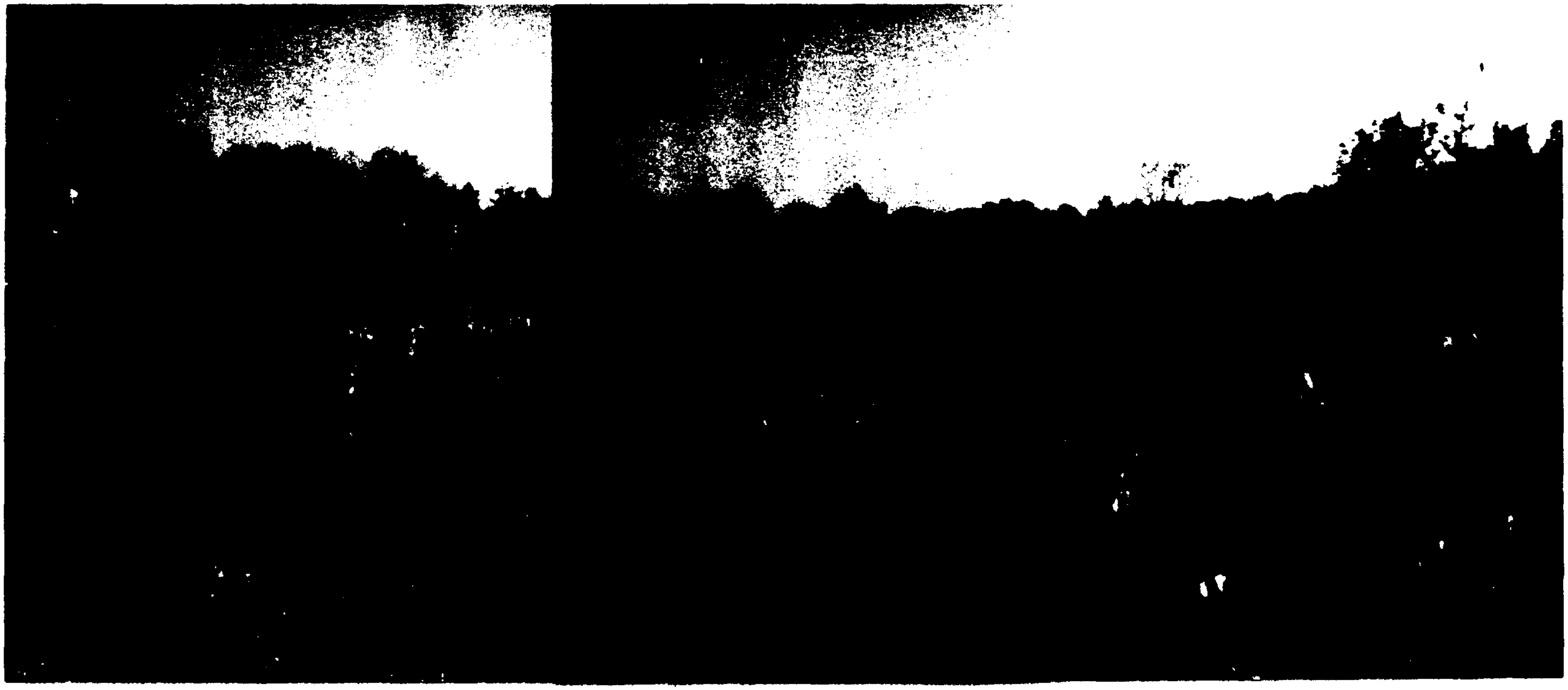


Photo 2: The western half of the northwestern portion of the former landfill area, looking north.

SKINNER PRPS
SKINNER LANDFILL
WEST CHESTER, BUTLER COUNTY, OHIO
PROJECT NO. 72680.800

SITE PHOTOGRAPHS

RUST ENVIRONMENT & INFRASTRUCTURE

RUST ENVIRONMENT & INFRASTRUCTURE

Photo 3: Looking east at wetland area "A".

SKINNER PRPS
SKINNER LANDFILL
WEST CHESTER, BUTLER COUNTY, OHIO
PROJECT NO. 72680.800

SITE PHOTOGRAPHS

Photo 4: Looking west from the fenceline at wetland area "B".

Photo 5: Soil profile from wetland area "B".

Photo 6: Wetland area "C" (points C-5 through C-8).

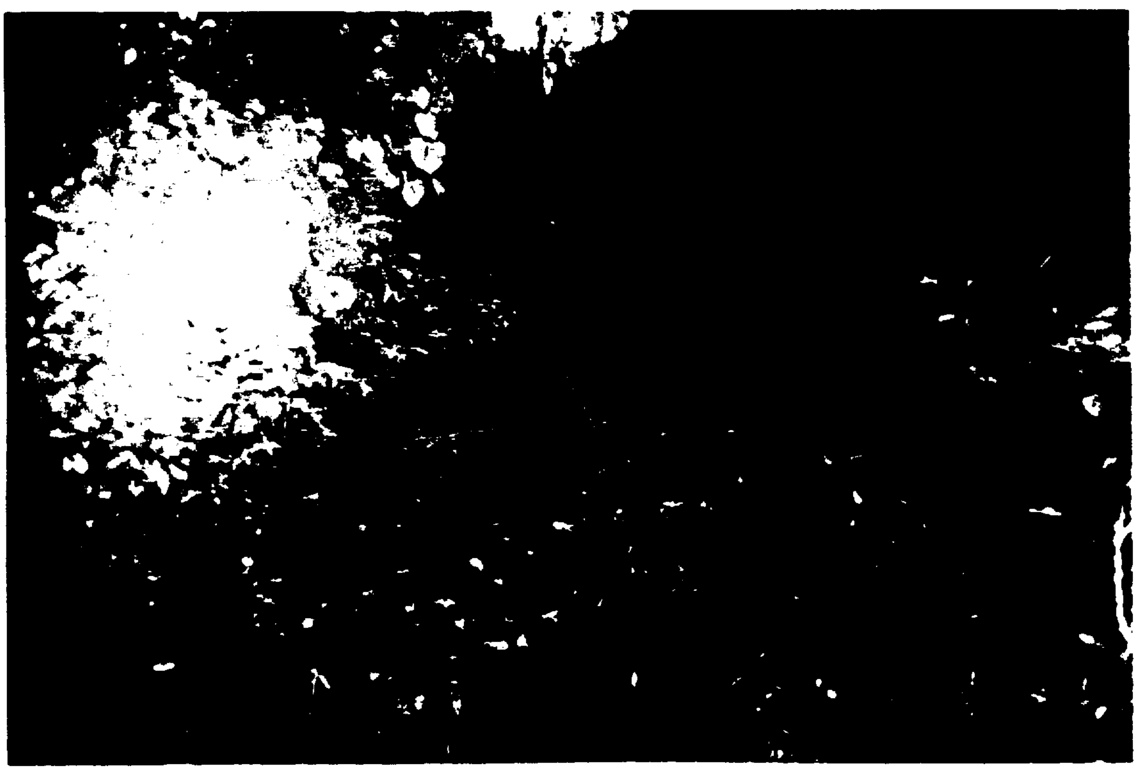


Photo 7: Wetland area "C" (points C-9 through C-1[illegible]

SKINNER PRPS
SKINNER LANDFILL
WEST CHESTER, BUTLER COUNTY, OHIO
PROJECT NO. 72680 800

SITE PHOTOGRAPHS

RUST

Photo 8: Looking south at wetland area "D".

Photo 9: Looking north from point "E-1" at wetland area "E".

Photo 10: Looking south at wetland area "E".

Photo 11: The eastern portion of wetland area "E".

Photo 12: The northwestern corner of wetland area "E".

APPENDIX 4-X

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Reed, Porter, 1988. National List of Plant Species That Occur in Wetlands: Ohio. U.S. Fish and Wildlife Service, Biological Report.

U.S. Department of Agriculture, 1982. Soil Survey for Butler County, Ohio.

U.S. Fish & Wildlife Service, Draft National Wetland Inventory Map for Glendale, Ohio 7.5-minute topographic quadrangle, 1985.

U.S. Geological Survey, 7.5-minute topographic map for Glendale, Ohio, 1987.

Weishaupt, Clara, 1985. A Descriptive Key to the Grasses of Ohio Based on Vegetative Characters. College of Biological Sciences, Ohio State University, Columbus, Ohio.

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<u>SKINNER LANDFILL</u>
REMEDIAL DESIGN
FINAL DESIGN (100%) PHASE I REPORT

VOLUME II OF IV, PART 2

THE FOLLOWING MAPS MAY BE VIEWED AT THE U.S. EPA RECORD CENTER, 77 WEST JACKSON BLVD., 7TH FLOOR, CHICAGO, ILLINOIS

1) LANDFILL COVER DESIGN
2) SITE CONSTRUCTION USE PLAN
3) CONSTRUCTION EROSION CONTROL PLAN
4) CONTAMINATED SOIL EXCAVATION PLAN
5) SUBBASE GRADES (SITE PREPARATION)
6) FINAL GRADES (TOP OF CAP GRADES)
7) POST CONSTRUCTION SURFACE WATER CONTROL
8) GAS MANAGEMENT PLAN (VENTS AND PROBES)
9) ON-SITE BORROW AREA GRADING PLANS
10) GROUNDWATER INTERCEPTOR DESIGN - 1
11) GROUNDWATER INTERCEPTOR DESIGN - 2
12) DETAILS - 1
13) DETAILS - 2
14) DETAILS - 3